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THE COMMERCIAL AND DYNAMIC EFFICIENCIES OF THE STEAM ENGINE.

By PROF. ROBERT H. THURSTON.

[American Association for Advancement of Science; Minneapolis Meeting, August, 1883.]

The writer, at the meeting of 1882 of the American Association for the Advancement of Science, in a paper on a newly discovered "Absolute Limit to Expansion in the Steam Engine,"* gave what he has called the "General Equation of Steam Engine Efficiency."

In that equation it was assumed that the annual expense chargeable to, or variable with, the cost of engine maintenance and operation could be reckoned per unit of volume of steam cylinder without serious error. Although this is often, and with large engines generally, true, and although it may not lead to appreciably erroneous results, it may yet be sometimes advisable to adopt the more general formula about to be given and which may be made as general and as exact as may be desired.

In the equation above referred to, an approximate form was adopted —making the denominator variable with variation of the waste by cylinder condensation and leakage, instead of the second term in the numerator—for the purpose of obtaining a more manageable, although less precise expression.

The equation to be here given may be used when greater precision

* Trans. Am. Assoc. for Adv. Science, 1882; JOURNAL OF THE FRANKLIN INSTITUTE, September, 1882.

and a wider range of application is thought desirable than could be secured with the equation already given for general use in earlier papers.*

Adopting the nomenclature assumed in the earlier treatment of the subject, but making the "costs of engine" vary as a function—$r^m v_1^m$—of the size of steam cylinder or volume traversed by the piston per stroke, and the ratio of expansion.

A = total annual cost of all items variable with size of steam cylinder and per unit of volume; *i. e.*, "cost of steam."

$r^m v_1 = v_2^m$ = rate of variation of such costs with variation of size of cylinder; such that

$A r^m v_1^m = A v_2^m$ = total annual costs so variable for an engine of volume: $v_2 = r v_1$;

B = total annual cost, per unit of volume of steam supplied, of all items variable with such volume; *i. e.*, with "cost of steam;"

C = total of all annual costs invariable within the range of the problem;

$a = \frac{v_s}{v_2}$ = ratio, volume of steam supplied at full stroke divided by volume of cylinder—a quantity always greater than unity.

r^q = the measure of the variation of this relation with variation of the expansion-ratio; so that

$a B r^q v_1$ = total annual cost of all items so variable for any engine supplied with a *net* volume of steam v_1 per stroke and working with a ratio of expansion r.

K = total annual cost of all items in doing total work;

n = index of the expansion curve, in the equation $p v^n = p_1 v_1^n$ = constant;

p_1 = initial steam pressure;

p_b = total back pressure, including all useless resistances;

p_3 = back pressure in the steam cylinder;

R = number of revolutions of crank per annum;

W = work done per stroke by the given engine under the assigned conditions;

Also make the values

$$M = \frac{A}{Ba} \quad ; \quad N = \frac{A + C}{Ba}.$$

* Trans. Am. Soc. Mech. Eng'rs, 1882; JOURNAL OF THE FRANKLIN INSTITUTE, February to July, 1882.

The annual cost of doing the given work will consist of the sum of the annual costs variable with size of engine, $A\, r^m\, v_1{}^m$; the annual costs variable with steam supply, $a\, B\, r^q\, v_1$; and the invariable cost, C; *i. e.*,

$$K = A\, r^m\, v_1{}^m + B\, a\, r^q\, v_1 + C \tag{1}$$

which is a minimum when the variable part is a minimum, and this latter is a function of the work to be done and of size of engine taken to do that work.

We may thus take up the problem of the designer and of the buyer of a steam engine:

Given: The work to be done by an engine.

Required: The ratio of expansion at which the demanded power may be furnished most economically.

This problem being solved, and this ratio of expansion being determined, the mean pressure becomes known and the necessary size of engine is easily calculated.

The work done per stroke is

$$W = p_1 v_1 \frac{n - r^{1-n}}{n-1} - p_b\, r v_1 = \text{Const.} \tag{2}$$

It is necessary to "minimize"

$$\frac{K}{2\,R\,W} = \frac{A\, r^m\, v_1{}^m + B\, a\, r^q\, v_1}{2\,R\,W} = \frac{A\, r^m\, v_1{}^{m-1} + B\, a\, r^q}{2\,R\left(p_1 \dfrac{n - r^{1-n}}{n-1} - p_b\, r\right)} \tag{3}$$

If $M = \dfrac{A}{Ba}$; we may take

$$u = \frac{M\, r^{m-1}\, v_1{}^{m-1} + r^{q-1}}{n\, r^{-1} - r^{-n} - (n-1)\dfrac{p_b}{p_1}} \tag{4}$$

and, making $\dfrac{du}{dr} = o$, we obtain a minimum, and "Maximum Commercial Efficiency" when

$$\frac{Mmn\, v_1{}^m r^{m-1} - M(m+n-1)\, v_1{}^m r^{m-n} + q\, n\, v_1 r^{q-1} - (q+n-1)\, v_1 r^{q-n} =}{M(m-1)(n-1)\, v_1{}^m\, r^m + (n-1)(q-1) v_1\, r^q}$$

$$= \frac{p_b}{p_1} \tag{5}$$

When $m = 1$, as in the usual case, nearly, cost of engine becomes directly proportional to cylinder volume, and

$$r^{-1} - \frac{q+n-1}{qn} r^{-n} + \frac{M}{q} r^{-q} - \frac{M}{q} r^{-q-n} = \frac{(n-1)(q-1)}{qn} \frac{p_b}{p_1} \quad (6)$$

When $q = o$ and $a = 1$, we have the ideal case of the perfectly non-conducting cylinder, and

$$r^{-n} - M \frac{n - n r^{1-n}}{n-1} = \frac{p_b}{p_1} \quad (7)$$

When seeking "Maximum Efficiency of a Given Plant" that ratio of expansion is determined at which a given engine in place can do work with maximum economy, *i. e.*, the maximum work which it should be expected to do. Then we have simply to substitute N for M in the above expression. The quantity of power thus determined could, it will be found, be done, however, by a somewhat larger engine operated at a somewhat higher ratio of expansion than is obtained by the solution of this second problem.

When M and N are made zero, the ratio of expansion determined is that giving "Maximum Efficiency of Engine" and

$$r^n = \frac{p_1}{p_b} \quad (8)$$

Finally, when, in this last expression, p_b is replaced by p_3, the back pressure in the cylinder, we have

$$r^n = \frac{p_1}{p_3} \quad (9)$$

and the ratio of expansion is determined which gives "Maximum Efficiency of Fluid."

Hoboken, N. J., January 1883.

The Improvement of Wells.—Emilio Bianchi has turned his attention to the impurities of surface drainage which so often contaminate well water. He proposes to remove all wooden pipes and casings, and to substitute tubes of cement, which can be made at small cost, and which can preserve the water in perfect purity. These pipes can be formed of a series of tubes, united together by water-tight joints, so as to shut out lateral and superficial infiltration, and secure an abundant supply of pure water, if the well is sunk deep enough. In extreme cases, he proposes, after reaching a certain depth, to place a diaphragm or filter, made of béton and carbon, so as to oblige the water of the well to pass through it.—*Il Politecnico*, Sept., 1882. C.

THE STEAM ENGINE INDICATOR AS A DETECTOR OF LOST MOTION.

By Robert Grimshaw, M. E.

[Read by title at the Stated Meeting of the Franklin Institute, September 19, 1883.]

The improved steam engine indicators of the present day, while the legitimate successors of the original and long secret invention of James Watt, in the matter of merely showing the performances in the cylinder and valve-chest, and measuring horse-power, are gradually getting a wider application; and it is to one of their new applications, recently discovered, and not, to my knowledge, heretofore made public, that I desire to call your attention for a few moments.

A very intelligent engineer, Mr. Gilman W. Brown, of Boston, had put in his hands for remedy a most pronounced case of pounding in a high-speed engine. This machine thumped at high speeds and at slow speeds; at high pressures and at low pressures; at early and late cut-offs, and under apparently all imaginable conditions of lead and compression. Wherever it was attempted to locate the thump, it appeared somewhere else; or at least was not where suspected.

There evidently was only one way to find out where that thump was:—to make it record itself—something which had never before been done, but which was now to be effected.

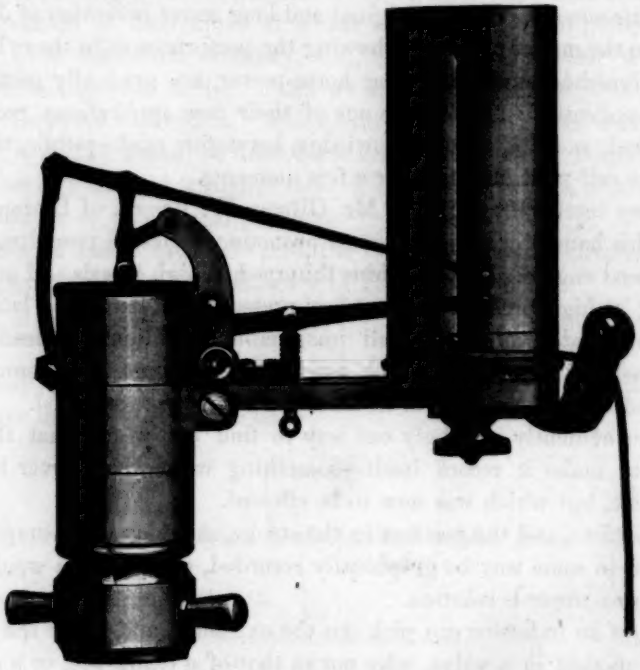
If the time, and the position in the stroke, at which the thump came in, could in some way be graphically recorded, the problem would be a long way towards solution.

Now, if an indicator can pick out the existence, and locate the time, of lost motion in a valve, why not in that of a crank-pin, or a cross-head pin, or a main bearing?

It is evident that whatever trace the tell-tale instrument should make of lost motion, outside of the valves, should not interfere with its record of the valve functions; and the natural deduction was that there must be another trace, necessitating another marking-point, in no wise connected with the indicator-piston, nor influenced by the steam-pressure.

To effect this, there was added to a "Crosby-Brown" indicator a second multiplying-lever, having a vertical motion only, and bearing a pencil making a trace underneath, and parallel, to the atmospheric and vacuum lines of the usual "diagram." This lever was pivoted to

a little standard on the connecting-piece of the instrument, and the pencil position was adjustable in height by a spring and screw, the latter formed on a light rod passing through the connecting-piece. Vertical motion of this rod caused the pencil to vibrate vertically. If the rod was kept at a constant height, the pencil would trace a horizontal line partly around the paper cylinder; but any pull on the rod would make a jog in the tracing.



The main bearing being slacked up, a vertical metal lever was pivoted to the bed-plate, so as to bear against the far side of the main-shaft (assumed to be truly cylindrical, and tested for this purpose, beforehand). The upper end of this lever was connected by a wire, or inelastic cord, passing around a guide-pulley, to the lower end of the vertical rod on the lost-motion lever of the indicator, and all slack taken up, and held out by the spring on the vertical rod.

It is evident that if the main shaft has any horizontal movement, it will cause horizontal vibration of the free end of the lever bearing against it, and thus tighten or slacken the cord and produce a vertical movement of the lost motion lever on the indicator. This

will cause a jog, either below or above, in the supplementary horizontal line representing the crosshead path, and will indicate, beyond all question, where the lost motion commences, how long it lasts, in which direction it is from the normal, and when and where it stops.

By the aid of this rig, its inventor effectually cured the hitherto incorrigible engine.

New York, September 8, 1883.

THE WATER SUPPLY OF CITIES IN ANCIENT TIMES.

By WALTER ATLEE, C. E.

It would seem to be particularly interesting at the present time to give some account from ancient authors of the manner in which the famous water supplies of Rome and other cities, celebrated in antiquity, were conducted.

Ever since men have increased in numbers, and have dwelled together for a more or less time in one locality, great attention has always been given to obtain a permanent and abundant supply of pure water.

Among pagan nations water was regarded with such reverence that it was customary to give names to fountains and springs, and to place them under the protection of the gods.

The ancient Egyptian priests, in order to show that all things could subsist only by the virtue of this element, carried solemnly, with religious respect, into the temple where their god was supposed to reside, an ornamental vase filled with water, and there prostrating themselves on the earth, with their hands raised, gave thanks to the divine goodness for his admirable inventions.*

In ancient Rome was celebrated annually on the III Ides of October (October 13), the feast of the fountains, under the name of Fontanalia. During the half day which the celebration lasted, the fountains and wells were crowned with flowers, and wreaths were thrown into the springs of running water.

The Germans, even a long time after the introduction of Christianity, continued in certain districts to make pilgrimages to several fountains consecrated to pagan gods.

If history furnishes but few and scattered accounts of the art of

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* Vitruvius lib. 8, preface.

furnishing cities with water, we find in national traditions and monuments the proof that the science of hydraulics dates back to the most remote antiquity.

We know that Persia possesses canals for irrigation, the origin of which is lost in the "night of ages," and which nevertheless continue at the present day to perform their functions.

In the province of Anachosia ruins of canals attest the former existence of a vast system of irrigation.

At Memphis is the ancient aqueduct of Sestorius.

Semiramis constructed at Babylon her celebrated aqueduct.

The city of Jerusalem was supplied by water through an aqueduct built by Solomon. The whole plain at Persepolis was at one time traversed by hydraulic constructions, the ruins of which show that conduits made of stone and pottery large enough for a man to enter were supported by masonry above the level of the plain.

The traveler Tavernier went from Aleppo to Ispahan by the route of the Great Desert, and arrived at a large abandoned palace before the entrance to which was a reservoir communicating with a canal, then completely dry, the bottom and the roof, which latter was level with the surface of the ground, were constructed of bricks. The Arabs who accompanied Tavernier said that the canal had served to bring water from the Euphrates, which was at least fifty miles distant.

Joseph's well, at Cairo, although of more recent date, is probably the most wonderful subterraneous work ever performed by man. A brief and clear account of this structure is given by Ewbank.

There is also at Cairo a long aqueduct, built of masonry, which for its greater length is supported by arcades, constructed about the same time as Joseph's well.

The engineering skill of the ancient Greek is shown by the celebrated aqueduct constructed by Eupalinos, of Megara, which Herodotus mentions as one of the wonders of the Island of Samos;* this exceedingly interesting object for the archæologist pierces, for two and a half miles, the heart of the mountain back of the town, whose inhabitants it supplied with water from a perennial spring.

From an article in Macmillan's Magazine for August, 1883, we learn that a priest named Cyril, from the monastery of the Holy Trinity, last spring, while plowing, discovered the long lost southern entrance of this aqueduct. At a cost of 20,000 francs the Samiotes

* Herod. lib. 3, ch. lx.

have now almost completed the restoration of the ancient channel with the view of again utilizing it, in supplying the town with water. Amongst the ruins of the aqueducts of ancient Greece that of Patara, in Lycia, is most interesting. It consists of a syphon constructed with cut stones supported by an arch in cyclopean masonry, dating to the most remote antiquity.

But it is, above all, the Romans who particularly attract our attention by their hydraulic constructions, the magnificence and daring of which surpass those of all other nations.

Rome is the only city of antiquity of which we have any detailed account of the administration of the collection, conveyance and distribution of water.

The Romans, enabled by their enormous wealth to gratify their love of display and indulgence in luxurious habits, constructed those monuments of hydraulic engineering which Frontinus speaks of as being "worthy of the greatest care, since they are a principal testimony of the grandeur of the Roman empire," "rem enixiore cura dignam, cum magnitudinis romani imperii id præcipuum sit indicium."*

At the fall of the Republic, 45 B. C., Rome, according to Frontinus, possessed four aqueducts. The Appia, constructed in 442 Roman era, by the emperor Appius Claudius. The Anio Vetus, built in the year 481 Roman era; the Marcia and the Tepula.

The emperors Augustus, Caligula, Claudius and Trajan constructed at Rome other aqueducts, more magnificent than those of their predecessors, so that at the time of Frontinus (850 Roman era, or 97 B. C.) there existed nine aqueducts, namely, (in addition to the four already mentioned,) the Julia, the Virgo, the Alsetina and the Claudia.

The aggregate length of these most useful monuments was $267\frac{3}{10}$ miles. For $228\frac{3}{10}$ miles the channels were entirely underground, and for 39 miles above the surface of the ground, of the latter $34\frac{7}{10}$ miles were supported by arcades or ranges of arches.

The following brief account of the character and construction of the Roman aqueducts is mainly taken from "Les aqueducts Romains" by M. Belgrand.

The first aqueducts, the Appia, the Anio Vetus and above all the Marcia, bear the robust character of the masonry of the earliest ages, they were constructed of cut stone, very simply dressed, but adjusted

* Frontinus, ch. cxix.

with precision, so that we see that the engineer relied more upon the resistance of the stone than that of the mortar.

The Tepula aqueduct was built in 627 Roman era, or but nineteen years after the completion of the Marcia, nevertheless the mode of construction was different; during that time the Romans had become masons and understood that with good mortar and rough material, they could produce a construction as solid as with cut stone and at a much less cost.

The same mode of construction was employed in the other aqueducts, with the addition of the introduction of bricks, except in that of the Anio Novus, which, when it approached the city, surmounting the Claudia took a character of magnificence, the rough materials being abandoned and cut stone entirely employed.

The cross sections of the channels through which the water ran varied from 3 to 8 feet in height, by $2\frac{1}{2}$ to 5 feet in breadth, the bottom was horizontal and the sides perpendicular to it; the shape of the top or covering varied even in the same aqueduct, it being sometimes arched and at others peaked, and sometimes horizontal or parallel with the bottom.

The necessity of maintaining the aqueducts at a gradual inclination from their sources in the mountains to the place of delivery of the water in the city, forced the engineers, when they came to the numerous abrupt and deep ravines of the Apennines, to build sub-structures consisting of one or more arches; and often of several ranges of superposed arches where it was necessary to attain the required elevation.

In traversing the valleys it was often necessary to construct those arcades, the ruins of which are at the present day the wonder of all those who behold them, and no traveler considers that he has seen all the curiosities of Rome till he has visited at least the Plain Roma Vecchia, which is so remarkable for the ruins of the ancient aqueducts, especially for that of the Claudia surmounted by the Anio Novus, distinguishable by a high and exceedingly long line of arcades, extending beyond the power of vision.

The first four aqueducts constructed crossed the valley Degli Archi in the Apennines on magnificent arcades, the ruins of which are classed among the most curious of Italy.

There is an aqueduct bridge of the Anio Vetus composed of thirty-five arches, forming two ranges of arcades superposed, which travers the valley now called St. John.

The aqueducts Anio Vetus and Marcia descended by regular grades the mountains Spaccato and St. Angelo, and crossed the first ravine of the Apennines on the same bridge, also composed of two ranges of arcades. This ruin, now called St. Anthony's bridge, is considered very beautiful.

The want, more and more pronounced, of water at a higher elevation obliged the Roman engineers, especially in crossing the plain near Rome, to support the aqueducts on higher and higher arcades. Thus the elevation of the Marcia water being insufficient, the Tepula, nineteen years afterwards, was constructed at a greater altitude. Ninety-two years later the Julia was built, at a still greater elevation, and eighty-four years after the completion of the Julia, the water still being too low, the high arcades of the Claudia were superposed on those of the Anio Novus, crossing the plain near Rome at an elevation of one hundred and nine feet above its surface.

Not only at the Eternal City, but wherever the Romans extended their conquests and established cities, they built those gigantic hydraulic monuments which prove to posterity the great importance they attached to the enjoyment of an abundant supply of water.

Amongst the ruins of these beautiful constructions with which Gaul was dotted after the Roman conquest, there still remain several aqueducts in active service. That called at present the "pont du Gard" supplies the town of Nimes with water from the two springs, Aire and Airan. This aqueduct consists of a stone channel, 291 yards long, supported by three ranges of arches superposed and attaining an elevation of 160 feet.

At Metz the Moselle river is crossed by the aqueduct of Segovia, which brings water from the valley of Gorge, 23 miles distant.

A part of the water of Paris is still supplied by the Roman aqueduct passing near Arceuil.

Nothing gives a higher idea of the ancient splendor of the city of Lyons (Lugdunum) under the Roman emperors than the remains of the ancient aqueducts erected under Augustus, Tiberius, and Claudius to furnish the city with water.

But no country shared so well in grand Roman hydraulic monuments as Spain, where aqueducts and baths, or their remains, are found in most of the large towns. Those of Merida, Toledo and Tarragona are worthy of being compared to those of Rome itself. The aqueduct of Segovia, in spite of the ravages of time, of civil and political disturb-

ances, has never ceased to fulfil its ancient purpose, and to-day still furnishes the city with all the water necessary for its consumption. This aqueduct, nineteen miles in length, is justly celebrated for its admirable arcades, 700 yards long, composed of 109 arches supporting the channel at an elevation of 107½ feet above the valley.

Constantinople, the Rome of the East, was also justly celebrated for its water-supply brought to the city by the renowned aqueducts of the emperors Valens and Justinian.

The magnificent Carthagenian aqueduct carried its supply of water through mountains and over valleys for seventy miles; near the town of Undena it was supported by an arcade of more than a thousand arches, the elevation of the channel exceeding in some cases 100 feet above the surface of the ground.

Rome was long celebrated for the purity and freshness of its water. The Romans knew that spring and well waters alone were suitable for drinking and culinary purposes; that river water should be reserved for watering and washing streets and parks, to supply the needs of industry, ornamental fountains, and the celebrated amphitheatres where they were so fond of witnessing the famous naval sham-combats.

They knew that water to be good should be limpid, of a moderate temperature in winter and summer, inodorous and above all of an agreeable taste. Vitruvius* tell us "that we can, by means of several observations, know the quantity of the water of a district. If it flows along the surface of the ground, it is necessary before enclosing it in conduits to consider the physical condition of the inhabitants, if they are robust and have good color, and are not subject to diseases of the limbs or runnings from the eyes, the water may be considered fit for use. To test the quality of the water of a newly discovered spring it is necessary to throw several drops of it on Corinthian brass; and if it leaves no spots it is a sign that the water is excellent. It will be the same if, after having been evaporated, no mud or muddy deposit remains, and if vegetables boiled in this water cook quickly. Finally, we shall know that the water is light and very healthy if, being clear and beautiful in its source, it deposits in the places by which it passes neither moss, rushes, nor other impurities."

Until the 442d year after the foundation of Rome, or 310 years before the Christian Era, the inhabitants of the Eternal City contented themselves with water from the Tiber and from the most agreeable

* Lib. 8, ch. iv.

springs of the locality. They had at the foot of Mount Cœlis the fountain of Mercury; on the Palatin Hill the fountain of Saturn; from the famous grotto of the Louvre still flows the Lupercale water; in the same neighborhood is also the spring of Castor and Pollux.*

A. Cassio speaks also of four other springs—those of Lantulus, of Picus and Faune, of Cybele and of the nymph Egeria. For the waters of these springs and fountains the Romans had a profound veneration.

When Rome became powerful and rich she knew of no better manner in which to employ the plunder and slaves procured by her victorious arms than by constructing monuments as remarkable for their daring in architectural design as for their utility. She therefore constructed her famous aqueducts and thus availed herself of the remarkable advantage of being situated on seven hills at a distance not too great from the Apennine mountains which contain at a much greater altitude innumerable springs and lakes of pure water, by bringing for the health, comfort and luxury of her inhabitants this pure liquid to the summit of these hills by means of gravity through aqueducts, and thence distributing it throughout the city. The sources of the water of the Marcia and of the Claudian aqueducts are each 1030½ feet above their respective locations of delivery.

The water of the Marcian spring on account of its remarkable purity and agreeable taste was reserved by an edict of the Emperor Nerva for drinking.

Frontinus considered it a sort of profanation to have used this beautiful water for ordinary purposes.

The Romans having decided upon the springs or lakes from which they wished to augment the supply of water for the Eternal City, and having assured themselves that the sources were situated at an elevation sufficiently greater than that of the locality where they wished to deliver the water, first collected the water into reservoirs from which it ran through a channel built of masonry on a regular incline so that the water might run by the action of gravity to the storage reservoirs from which it was distributed, sometimes the water was made to pass through intermediate reservoirs for the purpose of purification by permitting the water to remain at rest long enough for the mud and other impurities carried along by the force of the motion of the water, to fall and be deposited on the bottom of the reservoir.

Near the seventh mile stone from Rome, on the Latin road, six of

* Belgrand, Idem p. 17.

the aqueducts emptied their supply of water into covered wells or reservoirs, from which the water continued its journey through aqueducts to the walls of the city, where it was received in "castelli,"* or water-towers, which were structures built of masonry enclosing a basin, near which were three reservoirs fed from the basin by three pipes which distributed the water equally.

These reservoirs were so placed that the centre one would receive in times of abundance the surplus water of the other two. From this reservoir of the centre the water was distributed to the public fountains and amphitheatres. The public baths were supplied with water from one of the other reservoirs. Private establishments obtained from the third reservoir their supply of water.

The water towers of the Julia and Claudia aqueducts were very important monuments, the ruins of which still remain.

Besides the public water towers there were private and special towers, which in the time of Frontinus numbered in the city of Rome 247. The public towers received the water directly from the aqueduct or from a branch of it, from which a portion of the water ran continuously through leaden pipes into the public fountains of the vicinity from which most of the people obtained the water necessary for domestic purposes.

The inhabitants of those portions of the city more distant from the public water towers into which the aqueducts emptied, were supplied with water from special towers to which the water was brought by conduits from the public towers. Private dwellings were supplied directly from the nearest water tower, or when situated at a too remote distance, the wealthy inhabitants were accustomed to build private towers for their special use. These towers and the dwellings were each supplied by their special conduits in lead or pottery; each conduit receiving its amount of water from an opening in the water tower, to which was attached horizontally a bronze pipe or gauge of a diameter and length, regulated by law, in proportion to the amount of water to be supplied; this diameter was maintained for a distance of twelve digits or nine inches, for if the opening alone were of the required diameter and a larger pipe were attached, immediately the pressure on the water would cause it to fill the larger pipe and thus supply a greater amount of water than that granted by the concession. This bronze pipe was therefore a sort of meter, which, if properly placed

* Vitruvius, lib. 8, ch. vi.

and the water of the reservoir maintained at a certain elevation, would indicate the amount of water supplied. From this gauge or meter the water was conducted through conduits in lead or pottery under the paving of the streets to the dwelling of the consumer, where it ran continuously, day and night, from a fountain, into a sort of basin or reservoir called the "impluvium," which occupied the centre of the interior court or "cavaedium," forming a part of the "atrium" or vestibule characteristic of the dwellings of the wealthy Romans.

This arrangement can be seen in all the larger houses at Pompeii; the smaller houses were not supplied with water, the artizan dwelled in his shop and procured the necessary supply from the public fountain.

The houses were thus supplied by water through special conduits directly from the reservoir, the water ran continuously in the court of the dwelling, and not through a large conduit, distributing the water to all the houses near which it passed, nor was the water distributed throughout the dwellings as is customary at the present day.

This mode of distribution rendered the expense of a private supply of water very great, for in addition to his portion of the expense of the maintenance of the tower of the district, the proprietor was obliged to bear the expense of laying the pipe, repaving the street, and maintaining in repair this conduit which was often necessarily of great length.

Through this custom of permitting the water to run continuously, much the greater quantity distributed for public and private service ran to waste.

The Emperor Nerva ordered this surplus water to be so used as to continuously flush the sewers and wash the streets; through some of the latter it ran continuously, a system so inconvenient that it would not be tolerated at the present day. Indeed, it would seem that the Eternal City would have become uninhabitable but for this abundant supply of water.

Frontinus considered this employment of the surplus water as one of the benefits of the reign of the Emperor Nerva, he says, "that the super-abundant water was no longer useless, the sanitary condition of the city was already changed, the air purer, the causes of that pernicious air, of that infamous air of the city of our forefathers were destroyed."

Vitruvius has left us a detailed account of the manner in which very long valleys could be crossed by means of the syphon; but the

Romans were only able to employ the syphon where but a small quantity of water was required, for they had not made sufficient advance in the working of metals to be able to economically employ any but lead pipes, and these were of such an inferior quality that the force of the water would often burst the pipes, especially in the curves.

According to the very careful calculations of M. Belgrand,* the water entering the nine aqueducts existing at the ascension of the Emperor Nerva, amounted to 252 million gallons each twenty-four hours, corresponding to about 252 gallons for each inhabitant of the city; about 27 million gallons of water were extracted inside and as much outside the city, in the name of Cæsar for the use of Imperial property, but much the larger quantity estimated at 83⅓ million gallons was extracted by fraud.

Frontinus tells us that he found fields irrigated, taverns and drinking places supplied by water, the proprietors having fraudulently turned the public water from the aqueducts.

Frontinus applied himself so assiduously to prevent these fraudulent extractions of water and with such success that he says, "the quantity of water recovered could be regarded as a new acquisition."† According to M. Belgrand, the amount of water was thus increased to 132 gallons for each person every twenty-four hours.

The water conceded for the public service in the time of Frontinus supplied 19 fields, 39 amphitheatres, 591 fountains and lakes, and 94 public establishments.

In the beginning the distribution of water for the city of Rome was very simple; all the water ran from the reservoirs into the public fountains, individuals could only use the water which fell from the inlet of the fountain into the basin. This water, after it had run from the basin of the fountain, was conceded to the public baths and for the use of fullers, they having obtained the right in consideration of paying an annual water-rent to the public treasurer.

Later, the water which escaped from the aqueducts through leaks was sometimes granted by concession to individuals. Frontinus‡ very justly remarks that these concessions favored frauds of many kinds, and were consequently very rarely granted by the emperors.

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* Les aqueducts Romains, p. 98 and 105.

† Frontinus, ch. lxxvii.

‡ Id. chps. cx and cxl.

The administration of the water-supply was confided sometimes to those holding the office of "censor," and at other times to those holding the office of "edile." The maintenance of the aqueducts was ordinarily contracted for, and the contractor was obliged to keep a certain number of slaves employed on the aqueducts. The names of these workmen, their duties, and the location in which they were to be employed were inscribed on the public bulletins. Their work was subject to the approval of the official in charge of the administration of the water-supply. The administrator regulated all the details of the service. On the days of the great performances in the amphitheatres no one was permitted to use even the most necessary water without a special order from the administrator.

There were very severe laws against those fraudently turning the water from the aqueducts; fields thus irrigated were confiscated, and the public contractors who permitted the frauds were arrested.

Those convicted of wilfully impairing the quality of the water were fined 10,000 sesterces ($280). To insure the execution of this two citizens in each district were chosen from among the inhabitants or property-holders in the neighborhood to oversee the public water.

These laws which punished so severely offences, which by public opinion were not considered dishonorable, were consequently very inefficacious, and must have been very little better than a dead-letter, for it would have required but little attention and care to have prevented the aqueducts from being opened and the water turned away, and to have prevented the planting of trees and the building of houses over the underground portions of the channels. Nevertheless, the most scandalous abuses are noted by Frontinus as being customary.

In the year of Rome 719 the supply of water became insufficient for the wants of the inhabitants. M. Agrippa, son-in-law of the Emperor Augustus, then holding the office of edile, completely restored the then existing aqueducts and constructed at his own expense two others, the Julia in the year 719, Roman era, and the Virgo thirteen years later. He reorganized and introduced admirable order into the administration of the water-supply of Rome, opened a regular account of the receipts and of the distribution of water for public and private concessions; he made laws to insure the preservation of the aqueducts and the maintenance of an abundant supply of water. He made out in detail the amount of water to be distributed to each water-tower and from which aqueducts the supplies should be drawn, the quantity to be employed

for public use and the amount to be distributed to individuals. He employed and maintained at his own expense a *family* of slaves, consisting of 240 men for the preservation of the water-supply, the care of the aqueducts, water-towers, and reservoirs.

Agrippa, having thus rendered his term of office when edile celebrated for the care he took to increase the water-supply by the restoration of the ancient aqueducts and by constructing two new ones, and above all, by the complete reorganization of the administration, so as to insure the preservation of these edifices and the abundant supply of water, was the first to be entrusted with the superintendence of the water-supply for life.

Those charged with the administration of the water-supply of ancient Rome were chosen from amongst the most illustrious citizens. Frontinus gives the names of his seventeen predecessors, who were all great personages or belonging to illustrious families; men distinguished for military or civic virtues, successful commanders, ex-consuls, and other dignitaries, were among those considered worthy and capable of being entrusted with the superintendence of the distribution of water and the preservation of the aqueducts. They alone were held to possess the talents, experience, and integrity necessary to properly conduct this most important department of the administration of the Eternal City.

Until the death of Agrippa the administration of the water-supply of Rome had been regulated by special authority, and was subject to no general law. The Emperor Augustus confirmed by an edict the permits recorded in the registers kept by the order of Agrippa, and having inherited the slaves employed for the preservation of the aqueducts, he donated them to the State. He established the gauges by which the quantity of water was regulated and limited to 25, the number of openings permissable in each tower. He nominated Messala Corvus to exercise the functions of administrator of the water, and empowered him to make laws regulating the supply. He granted him two assistants, and to them were accorded the same marks of dignity as were given to magistrates. When they exercised their functions outside the walls of the city, they were surrounded by a numerous escort composed of two lectors, three public slaves, an architect for each of them, clerks, messengers, tipstaves and criers equal in number to those accorded to the functionaries who distributed the wheat to the people. When they exercised their functions inside the city the lictors were withdrawn.

We thus see that the dignitary in charge of the maintenance of the water-supply of Rome was empowered to exercise force in performing his duties. It was decreed that during the fourth part of the year they were to attend to the public and private demands relating to the distribution of water, but this order fell into disuse either from the negligence or from the inability of some of the administrators, although the public treasurer continued to pay the tipstaves and other employees, who ought during that time to assist the administrators.

The administrators were especially advised to prevent any distribution to individuals without an order from the prince, so that no one might obtain any public water that had not been granted him, nor any one receive more than was conceded to him.*

This law had been so much neglected that Frontinus tells us "that by enforcing it he would be able, with the quantity of water recovered, to establish new fountains, and to supply new permits of the prince, and that it was necessary at all times to prevent fraud, by an active superintendence; in order to do so successfully, the aqueducts outside of the city should be visited from time to time, and also the water towers and public fountains, to enable the administrator to become acquainted with the nature of the concessions and to insure the flowing of the water night and day without interruption."†

Frontinus, in his "De Aquae Ductibus Urbis Romæ Commentarius," says, "Everything confided to us by the emperor requires our greatest care, but I feel myself naturally disposed as much by duty as by taste to acquit myself well of the new functions with which the emperor Nerva, a prince as zealous as well-intentioned for the interests of the republic, has just charged me in confiding to me the administration of the water of Rome, both for their use and for their purity and safety; a function which has always been exercised by the first citizens of the State. I thought that the best way was to do in this as I have done in other circumstances, in order to well understand the object of my enterprise, and I do not believe in fact that there is a surer way to be able to judge well of what should be done and what should not be done, nor is there any thing more shameful for an administrator than to act only by the counsels of his agents, which must certainly occur when the chief, from want of experience, is obliged to have recourse to those who should be under his direction, and who, although neces-

* Frontinus, ch. cii.
† Id. cii.

sary, ought only to be regarded as the hands and instruments of the administrator. This is why I have followed in this the same method that I pursued in several of my other functions, in arranging in order all the information that I could obtain concerning this object, united in one body in this commentary to serve me as a guide during my administration."

Those who wished to have a concession of the public water, had to obtain permission from the prince by a letter, which, if approved, was presented to the administrator of the water supply. The latter placed the affair in the hands of his assistant, who designated to the guardians of the water tower from which the water was to be drawn, the location of the opening to be made and the size of the gauge to be attached in accordance with the quantity of water conceded.

A concession lasted as long as the person or persons lived in the locality for which the water was granted. This right could not be transferred to a purchaser of the locality nor could it be inherited with the property. But the public baths had the perpetual use of the water which had once been accorded to them.

These long concessions were rendered necessary by the expense required to conduct the water to the locality to be supplied, often a long distance from the aqueduct, and requiring the construction of a private water tower or reservoir.

When a concession became vacant through the death or removal of the proprietor, it was publicly announced.

The administrators had been accustomed to stop the distribution of water immediately on the expiration of a concession, and to sell the right to the new proprietors or to others, but the Emperor Augustus ordered thirty days to be granted, so as not to stop too suddenly so necessary a supply and to give time to make the customary demands for the renewal of the concession.

Concessions were afterwards made of the surplus water which ran from the reservoirs and from the leakage of the aqueducts. This last was very seldom permitted by the princes for it was easy to enlarge the fissure so as to supply any quantity of water desired, and this flow aided the rapid destruction of the aqueduct itself.

Frontinus having measured the quantity of water entering the aqueducts, and having ascertained that it greatly exceeded that which was registered as having been employed for public use, or granted by concessions, set to work to find by what negligence or fraud this great quantity was lost to the state and to understand how to prevent it.

He tells us that he found gauges of a diameter larger than was permitted by the concessions, some of which were not marked, which proved the dishonesty of the agent who controlled the placing of the gauges, he having been bribed to furnish more water than was justly due.

In certain water-towers the gauges were of the right size at the opening but instead of maintaining, this diameter for the distance required by law, a larger tube had been attached to the opening, thus furnishing more water than alloted by the concession as already described.

The locations of some of the openings were below that of others, thus on account of the greater pressure upon the lower openings they supplied a proportionately greater quantity of water.

In several towers, pipes were attached to the openings without any gauge, but were so arranged that they could be enlarged or contracted at the will of the guardian.

Another very reprehensible fraud on the part of the guardians was, when a concession changed hands, instead of using the old opening to supply the person obtaining the renewal of the concession, to pierce a new opening and to sell the water from the former for their own interest. Frontinus adds that the suppression of such a fraud should attract the especial attention of the administrator of the water, for it is his duty to take care not only of the water but also of the preservation of the towers for the latter would be very soon ruined if holes could be arbitrarily pierced.

In examining the condition of the different branches of lead pipes placed under the pavements, which circulated thoughout the whole city, they were found to be pierced with holes in many places by an instrument called a "pointer," the water flowing from these holes was sold by the purveyor for his own profit to all those wishing to arrange with him, the water being lead from these openings by private tubes to the dwellings.*

A large quantity of water destined for public use was turned from its legitimate course in this manner as Frontinus † proved by the increased amount received at the outlet of several pipes after the holes had been closed.

The labor required to preserve the aqueducts and to maintain a

* Frontinus, ch. cxiv.

† Id. ch. cxv.

proper distribution of the water, was performed by the men of two families of slaves.

One family* belonged to the public, having been inherited from Agrippa by his father-in-law, the Emperor Augustus, who gave them to the State as already mentioned. This family comprised about 240 men.

The second family, consisting of 460 men, belonged to the family of Cæsar, and was established for this purpose by the Emperor Claudius when he built his aqueducts. These men were classified according to the work they were required to perform; into guardians of the water-towers, inspectors, pavers, pipemakers, and laborers. A certain number of these men were required to live outside the city, in order that they might be able to repair promptly any damage caused by accidents to the aqueducts, for although the damage might be slight at the time of occurrence the force of the running water would very soon increase very materially any crevice in the masonry through which it might escape, and thus not only delay the supply of water to the city, but destroy the foundations of the aqueduct. Some of the guardians were lodged in the water-towers. All the other men dwelt in the vicinity of the water-towers and amphitheatres which were supplied with water, and were expected to continually hold themselves in readiness to aid in abating any damage caused by accident, and when necessity required to aid in directing the supply of water ordinarily running to several districts at once into any special district requiring immediately a more abundant supply.

Frontinus tells us that he found that these men, through the negligence of the overseers, were accustomed to leave the duties required of them for the public good and to work for their own individual profit.

To re-establish and keep order amongst so great a number of men as composed these two families, Frontinus required that the work to be performed on the morrow should be designated the previous evening; he also kept a record of the work performed each day.†

These men were paid by the public treasurer, and this expense was defrayed by the money paid for concessions of water. This amounted, in the time of Frontinus, to 250,000 sesterces‡ annually; this revenue

* It will be remembered that *familia, a family*, means properly, *the servants belonging to a common master.*

† Fr., ch. cxiii.

‡ This amounts to but $8,500 of our money, but the great difference of relative value must be taken into consideration.

was often taken for other purposes. The Emperor Domitian used it for his own benefit; Nerva caused it to be returned to the public treasury.

The expenses of the supply of water for Imperial properties were paid from the public treasury, as were also those for pipes and all expenses relative to the maintenance of the aqueducts, water-towers, and reservoirs, or public fountains.

The maintenance of the aqueducts was the especial care of the administrator, for they were exposed to many and frequent causes of damage, which it was necessary to foresee and prevent.

Accidents were occasioned by the ravages of age, by exposure to intense cold and heat, by the violence of tempests, through the fault of badly constructed work, and by the dishonesty of the proprietors of the fields adjoining the aqueducts, who fraudulently caused the water to escape from the channels in order to irrigate their land.

Those portions of the aqueducts supported by arcades suffered most from the effects of age and the violence of the mountain storms. Where the arcades crossed the rivers the foundations were much exposed to the violence of the current in times of floods. The channels in masonry along the flanks of the mountains were exposed to landslides and many other causes of accident.

It was necessary to bring to the execution of all work required to prevent these accidents, and the consequent interruption of the supply of water, great activity, and to have the work performed with great care.

The channels underground suffered less, not being exposed to the effects of intense cold or heat. Accidents to the channels could sometimes be repaired, while still maintaining the supply of water, by carrying it across or around the break through a temporary channel made of lead pipes held at the proper elevation.

A frequent obstruction to the passage of the water was the gradual deposit of mud on the bottom and sides of the channel, which formed in time hard and thick incrustations, and which gradually narrowed the channel till the passage of the water was finally entirely prevented. Sometimes the mortar would drop out and permit the water to escape, which would damage the walls of the channel and the masonry supporting it.

Only those repairs that were absolutely necessary were permitted during the heats of summer, so as not to interrupt the distribution of water

at the season when its use was the most required. Spring and autumn were recommended for this work, as the season most suitable, when the fresh masonry would not be exposed to the intense cold of winter, which would freeze the mortar before it was "set," nor would it be exposed to the heats of summer, which would absorb the moisture in the mortar and thus prevent it from forming a solid mass with the stones; for intense heat is as injurious as intense cold to fresh mortar. Moreover, there is no work which demands as much skill, precision and care as masonry required to prevent the escape of water; each piece must fit exactly according to the rules which most masons understand and few observe.* By preparing in advance all material required, and working with the greatest celerity, the passage of water was interrupted for the shortest possible period, and by working on but one aqueduct at a time, the city was not deprived of too great a quantity of water at once.

The administrators were empowered by the Senate when repairs were to be made to the aqueducts, to procure earth, clay, stone, sand and wood from the adjoining fields and have them transported across the fields if necessary, the damages having been previously appraised.

Fifteen feet were ordered by the Senate to be reserved on either side of the channels, no buildings nor trees being permitted within that space except where the aqueducts were entirely under ground, when the space was reduced to five feet. This law had fallen into such disuse that proprietors often enclosed this ground within their fields and used it for their own convenience, building and planting upon it as they pleased, and making roads over it, and even going so far as to prevent the employees of the administrator of the water supply from visiting those portions of the aqueducts, and thus these constructions were, from want of proper and timely attention, gradually destroyed. The real and prime cause of the destruction of the aqueducts was the negligence of the administrators entrusted with the care of the preservation of these magnificent testimonials of the civilization of ancient Rome; the workmen appointed to attend to the repairs profiting by the negligence, and following the examples of their masters, neglected their allotted work and attended to private affairs.

Pliny tells us that long before his time the City was deprived of the benefit of the water from the Marcia, the Julia, and Virgo aqueducts that the proprietors of the land adjoining the aqueducts had turned all the water to their own use; nevertheless, the water from these aqueducts

* Frontinus, ch. ex

continued to figure on the public register as amounting to 2242 quinaires daily, exactly as if it were regularly received and distributed.*

It is evident from what has been said in regard to water-supply that modern cities have not advanced beyond ancient Rome; indeed, in regard to abundance, no city has ever yet even contemplated supplying to its inhabitants such a large quantity. There, there was an abundant supply for every purpose; that which was used for drinking purposes was brought from a great distance and its freshness was retained by bringing it through conduits of stone and keeping in covered reservoirs, where it was exposed to the action of the air and at the same time protected from the rays of the sun. Great care was taken to prevent any pollution. As to the abuses in ancient Rome of the public water, it is not the place of the writer, nor his object, to remark upon them, or to make any comparison with those of modern times.

Many of the larger cities of both the old and new world have either recently imitated ancient Rome or are now contemplating so doing, by procuring their supply of water from long distances, from localities removed from all causes of pollution, and bringing it to the inhabitants by means of gravity through aqueducts.

OIL DRESSED BELTING.

By Joseph Sharp.

[Read at the Stated Meeting of the Franklin Institute, September 19, 1883.]

Transmission by belting is the rule, rather than the exception, in American manufactories and shops.

It has the advantages of high shaft speed, wide shaft distance, cheapness, and lightness, and of slipping in case of a clog in the machinery, thus preventing serious loss and accident by breakage.

One thing which sometimes stands in its way is that it is not as sure, under very heavy work, as gears are, and requires for such heavy work very great pressure on bearings, to prevent slipping.†

The very principle of its action demands a certain amount of slipping, say from 2 per cent. as a minimum, to 15 per cent. or 20 per cent. as a common occurrence.

This cuts it out from many applications where regularity and proportion of velocity-ratio are necessary.

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* Pliny, lib. 31, ch. xxv.

† The minimum slippage, with one belt, is 2 per cent.; where there are several belts between the motor and the machine there is proportionately more slip.

Anything which renders it more efficient and regular is worthy the particular attention of all manufacturers and mechanics. It is also desirable to increase the regularity and proportion of velocity-ratio.

There are locations, as in paper-mills, tanneries, etc., where those kinds of belts which are susceptible to hygrometric influences cannot be used.

Among the many materials for belts, used and offered for use, may be enumerated, in about the order of their frequency—

1. Tanned leather.
2. So-called "rubber" or "gum."
3. Canvas.
4. "Fulled" leather.
5. So-called raw-hide.

The first has many advantages in strength and convenience of repair over all others. But as ordinarily prepared it has not the driving power of rubber under the same conditions, as has been proved by the experiments of Cheever, Grimshaw, and others.

It has, too, the demerit of being exceedingly hygrometric, hence unfit for use in damp places, or those varying suddenly and greatly in humidity.

The fact is that the inferior driving power of oak-tanned and hemlock-tanned leather, as compared with rubber, is largely due to their stiffness.

This causes transverse wrinkling of their under surfaces, and for any considerable width and thickness of belt, is most disadvantageous on pulleys of small diameter, as has been most conclusively proved by Mr. R. Grimshaw, member of your Institute. This gentleman presented the results of his tests in this direction, in his paper read before your body, on the "Influence of Pulley Diameter on the Driving of Belts."*

For a long time beltmakers have denied that this was so. But the tests and figures to which I refer leave us no longer a doubt on this subject.

It is better to accept a fact, however unpleasant, and to take action in accordance therewith, than to deny it.

I have the honor to announce that I have discovered, and successfully put into operation, a method of "oil-dressing" leather, which gives results which far exceed oak-tanned leather from the same green

* Jour. Franklin Institute, Vol. lxxxiii, 460. (June, 1882.)

hides, in tensile strength and in grip or driving power, and produces a durable and waterproof material suited for use in the most exposed and humid conditions.

Most oil-dressed leather belts, and imitations thereof, while waterproof enough, have been deficient in pliability and strength, and still more so in driving power.

I take pleasure in submitting to the inspection of the members of the Franklin Institute samples of the "oil-dressed" belting, and in appending hereto extracts from the editorial columns of the *American Journal of Railway Appliances*, of New York, dated July 16th and August 15th and 31st.

I make, however, by the consent of the editor-in-chief, a few corrections that are manifestly only typographical, and add to the tables the horse-powers at the more usual belt-speed of 3,300 feet per minute.

CINCINNATI, *September* 6, 1883.

APPENDIX.

From *American Journal of Railway Appliances*, July 15:

"The following figures show the grip of a four-inch single oil-dressed leather belt, flesh side driving, 180° arc, on a thirty-six inch turned cast-iron pulley.

"In the first column are given the weight in pounds, hung on one end of the belt, and marked T^2; in the second, the amount hung on the other end to make the belt slip on the pulley (marked T_1). The third column gives the difference between these two, *i. e.*, the net-grip, or driving power, in pounds. Supposing the belt to have this same grip at a velocity of 1,000 lineal feet per minute, the horse-power would be as given in the fourth column."

Weight, lbs. on slack end. (T_2)	Weight on other end, to cause slipping. (T_1)	Difference, or grip in pounds. ($T_1 - T_2$)	Horse-power at 1000 feet lineal speed per minute.	Horse-power at 3300 feet lineal speed per minute.
100	233⅓	133⅓	4·1	13·36
150	323	173	5·24	17·3
175	353⅓	178⅓	5·41	17·83
200	373⅓*	173⅓	5·25*	17·33
211	393⅓	182⅓	5·5	18·2

* Probably slipped easier than expected, by reason of a slippery spot in the belt.

From *American Journal of Railway Appliances*, July 31:

"The same piece of 4″ single 'oil-dressed' leather belt which was run 'flesh side to' over the 36″ cast-iron pulley, as per the records in No. 1 of this series, was then run 'grain side to' over the same pulley, with the following results:

Weight in lbs. on slack side. (T_2)	Weight required to cause slip. (T_1)	Net grip in pounds. (T_1-T_2)	Horse power at 1000 feet belt speed.	Horse-power at 3300 feet belt speed.
75	206⅔	131⅔	3·99	13·16
100	240	140	4·24	14·
150	273⅓	123⅓	3·73*	12·3
175	323	148	4·48	14·8
190	346⅔	156⅔	4·75	15·66
200	366⅔	166⅔	5·05	16·66
246	420	174	5·27	17·4
250	433⅓	183⅓	5·56	18·36
302	573⅓	271⅓	8·02	27·16

"Noting the 'horse-power at 1,000 feet speed,' increasing the slack tension 100 per cent., from 100 to 200 pounds, appears to increase the net grip or horse-power only $\frac{\cdot 81}{4\cdot 24}$, or not quite 20 per cent.

"It will be noted that the grain side of this new 'oil-dressed' belt drove rather better than the flesh at 100 pounds, slack tension, but at 200 pounds this was reversed. If we can depend on these figures, that means that the hair side has naturally a better driving surface, but that increasing the tension flattens down the roughnesses on the flesh side, and thus produces a better driving surface than the hair side under the same tension."

From *American Journal Railway Appliances*, August 31:

"The first two articles of this series went to contrast the driving power of the hair and flesh sides of an oil-dressed belt, on a turned cast-iron pulley, under various degrees of tension. The same belt was also tried, 'hair side to,' on a new 36-inch poplar-faced pulley made by Dodge Bros., Mishawaka, Ind.; and as the driving power of wooden pulleys is as a rule greater than that of those with iron rim, the tests

* In this set a greasy place evidently caused slip when 150 lbs. were applied.

were commenced with a very light tension; only 25 pounds at the slack ends.

"The results were as follows:

Weight in lbs. on slack end. (T^2)	Weight required to cause slip. (T^1)	Net grip in pounds. (T^1-T^2)	Max. horse-power at 1000 feet belt speed per minute.	Max. horse-power at 3300 feet speed.
25	116½	91½	2·76	9·15
50	290½	240½	7·3	24·0
100	760	660·	20·	66·0
125	886⅔	761⅔	23·08	76·1
150	1020.	870·	26·4	87·0
200	1186·7	986·7	29·9	98·6
250	1493·	1243·0	37·66	124·3

"We believe these figures to be unparalleled in the history of belt transmission. Comparing the grip at 100 pounds, slack tension, with that at 200 pounds, we find it increased $\frac{8{\cdot}99}{20}$ = practically 45 per cent.; but comparing the grip at 100 pounds, slack tension, with that of the same side of the same belt on the turned cast-iron pulley we find them as 20 to 4·24, or practically as 100 to 17, or about 6 to 1 in favor of the poplar pulley. That these extraordinary results were in a measure due to the excellence of the belting, is shown by the records of tests made almost a week before with a 6-inch double oak-tanned belt (hair side to), 180° contact on the same 36 new poplar-faced pulley. We had at that time no 4-inch single oak-tanned belt; but it is not very unfair to the oak-tanned belt to compare the 6-inch double belt at 150 pounds, slack tension, with the 4-inch single at 100 pounds. The results were as follows:

Weight in lbs. on slack side. (T^2)	Weight on tant side to cause slip. (T^1)	Net grip in pounds. (T^1-T^2)	Max. horse-power at 1000 feet per minute.	Max. horse-power at 3300 feet.
100	520⅔	420⅔	12·75	42·0
125	780⅔	655	19·8	65·5
150	833⅓	683⅓	20·7	68·3
175	920*	.....	.....	.....
200	1133⅓	933⅓	28·3	93·3

"Suppose we take two-thirds the drive of the six-inch double belt, and compare with the entire net grip of the four-inch belt. We get, then, as follows:

Tension on slack side (T^s)	$\frac{2}{3}$ Horse-power of six-inch double oak-tanned.	Horse-power of four-inch single oil-dressed.	Per cent. superiority in favor of oil-dressed.
100	8·5	20·	135
125	13·2	23.08	74
150	13·8	26·4	91
200	18·9	37·66	47

"These figures show such a variation that, lacking further examination and knowledge of the surfaces of the two belts, all that we are justified in saying is that the new single oil-dressed belting has a greater grip than new double oak-tanned; and that the lighter the tension, the greater the superiority of the more pliable single oil-dressed belt."

DISCUSSION.

Mr. J. W. Nystrom remarked that the heading of the paper did not indicate its contents. He looked for a description of oil-dressed belting, and found instead the details of some experiments which indicated a smaller coefficient of friction in the belting used than that found in ordinary leather belting and, therefore, this new belting possessed inferior driving power.

He made detailed comparisons in each case, and showed that only the experiments with the wooden pulley, described in the last table, gave results equal to the average results of ordinary belting.

Mr. Hugo Bilgram:—The statement that "the very principle of its action (*i. e.*, that of belting) demands a certain amount of slipping, say from 2 per cent. as a minimum to 15 per cent. or 20 per cent. as a common occurrence," refers undoubtedly to the legitimate creeping owing to the elasticity of the belt, not to a bodily slipping which may amount up to 100 per cent. To say that the loss owing to creeping amounts to 15 or 20 per cent. is undoubtedly unwarranted. I believe that an amount equal to 2 per cent. is rarely reached in practice.

I wish to say, furthermore, that the experiments are tabulated in

* Hook that sustained the weights broke; belt did not slip.

such a way as to mislead regarding the capabilities of the belts. The comparison of horse-power is based on the tension of the slack side, while it should be based on that of the tight side, and is, therefore, devoid of practical value in the shape in which it is given.

REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS, ON THE COMPARATINE MERITS OF THE PRESSURE-GOVERNING GAS METER AND GAS BURNER.

HALL OF THE FRANKLIN INSTITUTE,
Philadelphia, March 26th, 1883.

The Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, to which was referred for examination the comparative merits of the pressure-governing gas meter and gas burner, report: In judging of the comparative merits of controlling the pressure of illuminating gas at the service meter and at the burner, the first and essential consideration is the requirement that an absolute, unvarying pressure be maintained throughout the premises to be lighted—premises of 60 feet horizontal extent and 30 feet elevation in common dwellings, to even 300 feet horizontal extent and 80 feet elevation in the large manufacturing establishments. The question is which of the two modes of regulation of gas pressure best secures the desired result.

We will assume, as we believe we are right in doing, that practically perfect appliances have been made in both cases. But to the successful application of the perfect governor meter there is opposed an insuperable obstacle which is not encountered by the governor burner. The fact that fluids meet with a certain definite resistance from friction, this resistance increasing in inverse ratio to the square of the diameter of the tube, and also the fact that elevation increases the pressure of illuminating gas so as to considerably more than overcome the loss by friction, the excess being about one-tenth of an inch in each elevation of 15 feet; these considerations make it impossible to maintain a uniformity of pressure throughout an ordinary manufactory, or even a common dwelling, by regulating the pressure at any central point. Your committee have at hand examples fully sustaining this objection to the governor meter.

While the differences of pressure alluded to, at any considerable horizontal or vertical distances from the meter are admitted by all, some have thought that these differences could be overcome by checks applied either in the burner or in the key. We are fully of opinion that such checks could never be so adjusted as to effectually control the flow of gas, and furnish the maximum degree of light, from a given amount of gas. This amount has been found by many experiments, to be obtained when gas burns at about ·25 of an inch ignition pressure. But it would not do to adjust a meter to give this pressure near the outlet, for at any considerable horizontal distance the light would utterly fail. Given half an inch pressure at meter outlet—and at 100 feet from this point, with the ordinary number of burners supplied at intervening distances from the ordinary run of gas pipe, such as prescribed by Gas Trust regulations, the pressure would probably not exceed one-tenth of an inch at the burner. In this case, to furnish the necessary pressure at a distance, the meter must be adjusted to give the gas an inch, or one and a half inches, pressure at the outlet. This excess of pressure in the immediate vicinity it is proposed to overcome by checks, either in the burner or in the key. If applied in the burner, by using smaller tips, this would, to be sure, check the flow of gas, but not increase the already too great ignition pressure. If the check is in the key it would require an independent adjustment in each burner, according to distance, and whenever only some of the burners were lighted the accuracy of the adjustment would be destroyed, and the regulation would prove a failure. Moreover, without taking into account the cost of the governor meter, which in ordinary houses is almost equal to that of governor burners, this plan would prove nearly if not quite as expensive as the use of reliable governor burners; and the throttle, being a fixed opening, is more likely to become clogged than the variable and continually varying opening of the governor burner.

Neither can this check be applied at any one place for each additional elevation, to govern all the burners on that level; for the low ignition pressure, alone admissible to obtain the best light, would not suffice for distant burners. Here also, therefore, each burner must have its regulator; and here also, if only a part of the burners are in use, the regulation is destroyed.

In favor of meter regulators, it is to be said, that they will act at somewhat lower street pressure than governor burners; but reliable

governor burners are produced requiring only ·6 of an inch initial pressure, which is only a slight increase over that required by meter regulators.

The committee is far from holding the opinion that a meter governor is of no benefit. On the contrary, it believes that a reliable governor meter may always be so adjusted as to secure some economy in the use of illuminating gas. But the question before the committee is, which method of gas-governing secures the more perfect economy and illumination.

On the whole, your committee concludes: 1st. That, owing to the friction of the gas in traversing the pipes, and also the comparative buoyancy of illuminating gas, it is impossible to maintain a uniform pressure of gas throughout even a limited establishment by use of a central or meter regulator.

3d. That reliable governor burners, *owing to their situation*, will preserve a uniform and unvarying pressure throughout any premises, however extensive, provided the street pressure is sufficient to supply the requisite amount of gas.

Approved Sept. 5, 1883.

H. R. HEYL, Ch'n Com. Science and Arts.

WM H. WAHL, Secretary.

Bleaching by Electricity.—Dr. Dobbie and M. Hutcheson have obtained important results by examining the action of the electric current on a solution of marine salt. The chloride of sodium is decomposed, as is well known, and if the solution is neutral, some of the chlorine is set free and hypochlorite of soda is produced; if the solution is alkaline, there is a simple production of the hypochlorite; if the solution is acid there is a yield of chlorine and of soda. The inventors have sought to apply this reaction to bleaching and their experiments seem to have been perfectly successful. Without going into details, it may be easily understood that the production of hypochlorite, or of chlorine, in a fabric which is impregnated with a solution of chloride of sodium, simplifies the operation of bleaching and renders it much more efficacious, because it takes place in the very pores of the tissue. The washings and the preparatory leachings may thus be dispensed with. Delahaye anticipated the possibility that the invention may lead to a new process for the direct manufacture of soda.—*L'Electricien*, No. 40. C.

MR. THEODORE D. RAND'S CRITICISM OF VOL. C_4, GEOLOGY OF CHESTER CO., PENNA.

The undersigned has expressed elsewhere his views of the defects of this volume, mainly however, confining himself (as he proposes to do in this instance) to those parts which bear upon his own work.

Mr. Rand has noted numerous and flagrant errors in the editing of that portion derived from Rogers.

Mr. Rand thinks that the map of the present writer "of a scale one inch to two miles, with the coloring in dispute, and one long line which has no geological value whatever, but is merely a temporary expedient" (p. vi.), is not a great advance over that published by Rogers twenty-five years ago. All the gneisses and mica schists south of the South Valley hill are embraced in one color. The trap (pp. 87 and 218) on the north side of the serpentine Easttown is not upon the map." That the map is very far from perfect, its author will readily admit, and yet this style of criticism is not unlike that often heard from those good old gentlemen during the late rebellion, who over their breakfast tables were wont to upbraid the officers of our Union armies for their military short-comings. It is easy to find fault with any geological map, and often with better reason than the above quotation shows. For instance, though it is true that Dr. Frazer's map is of one inch to two miles, Rogers' map, over which it is said to be no great advance, is on a scale of one inch to five miles. In scale the advance is thus sixty per cent. Nobody has disputed the coloring except of the belt which the editor of C_4 states that he introduced contrary to the wish of the author of the map. It is true that all the gneisses and mica schists south of the South Valley hill are embraced in one color, because the task of differentiation would have required a much longer time than was accorded, and this was explained to the Chief Geologist, who decided to publish, with a single color for all pre-Potsdam rocks.* But it is not a fact that Roger's altered primal is a well-

* This is what was done in the three counties of Adams, York and Lancaster. In the former two the pink color was devoted respectively to "Azoic" and "Azoic slates etc." In the latter two some attempt was made to separate the chloritic areas from the other eozoic or azoic, but it was not satisfactory in the eastern part of Lancaster; and further to the East in Chester it was as before stated a total failure in the time allowed, as was also the attempt to define the southern boundary of the hydro-mica series of the South Valley Hill. The Chief Geologist asserted in the letter of transmittal of CCC that, "Had the whole corps of the survey combined force on Lancaster County for a year it would not have been overstudied." "In fact, there is work in Lancaster County for a diligent geologist for ten years." What should he say of Chester?

defined rock; on the contrary, a more heterogeneous collection of gneisses, mica-schists, hydro-mica schists, chlorites, feldspar-porphyries, clays, and quartz slates than are found in the regions which he colored as altered primal, it would be difficult to collect together from the two hemispheres. The statement that "the trap (pp. 87 and 218) on the north side of the serpentine Easttown is not upon the map" is erroneous.

Mr. Rand says, "In papers published in the "Proc. Min. and Geol. Sec., Acad. of Nat. Sci.," 1880–81, pp. 9 and 28, Theodore D. Rand asserted that the serpentine in Radnor and Easttown, instead of outcropping in lines which if prolonged, would meet as mapped by Hall and by Dr. Frazer in the present volume, had an echelon structure the strike being from S. 40° W. to S. 60° W., while a line joining the exposures would be nearly E. and W., etc. . . . A map of outcrops was published with the text. If these outcrops are as stated, the fact is of interest; if they are not, the error should have been corrected."

If one subjects this statement to the same test of textual accuracy which its author imposes upon the subjects of his reviews, it will be found wanting. Mr. Rand gives the observations on which he founds his echelon theory in the first of these papers, with three lines of the theory itself (pp. 10, 11). In the second paper no allusion is made to the serpentine in Radnor and Easttown. To quote his own striking phrase, slightly altered: 'I am quite familiar with his two papers. I have searched for allusions to the Radnor and Easttown serpentines in the second of them without finding such allusions in it; and I believe, therefore, that they do not exist.' This, however, is mere word chopping. It is evident that Mr. Rand did announce a theory as to the position of the serpentines, which would be interesting if well-founded —the more so since it would seem to establish beyond a doubt either that there were a series of parallel faults and throws which had successively forced the western portions of the belt containing the serpentine to the north, or the easterly portion to the south, or that there was a zone of serpentine belts at an oblique angle to their strike. The first of these hypotheses will hardly bear examination, the boundary lines of the oldest formations show no such disjointing in the lines of these deposits as would necessarily result from a series of throws such as are imagined. The second presents an old observation in a new light, and is directly in accord with so much of the views of Mr. Charles Hall, the writer and many others as relate to the metamorphic—perhaps metaso-

matic—* origin of the serpentines; for nothing could more clearly preclude the idea of separate deposits of a given rock than its occurrence in small isolated patches in different horizons of different groups of other rocks with which, nevertheless, it agrees practically in strike. It is, therefore, with no prejudice against the hypothesis that the writer examined into its foundation.

As stated in Mr. Rand's first paper, in (*Proc. Min. and Geol. Sec., A. N. S.*), the first outcrop of his middle belt of serpentine in Radnor township ± ¼ mile N. E. of Radnor station strikes nearly E. and W., as do the rocks which bound it. The southern edge of black serpentine near Morrell's new house (N. E. of Radnor station) strikes about E. 5° N. The general dip is southwardly, and in following the road from Radnor station one passes obliquely to older strata. The perpendicular thickness of the serpentine from its southern to its northern edge is about 141 feet, while the road crosses the strike at an angle of 40° for a distance of about 660 feet.

The complexion of the rocks of this belt is very variable, and the dips across it vary from S. to S. 5° E–65° on the southern edge to S. 10° to 15° E–75° to 85° on the northern edge. It is doubtful if this change of dip has structural significance, but if so it implies a sharp anticlinal here. At a point about 106 feet perpendicularly across the strike is a schist which, while justifying the appellation of talc schist, resembles in its habit that which it in all probability originally was, viz.: a nacreous, perhaps chloritic-nacreous schist. At about 200 feet perpendicularly across the strike occurs a very much decomposed rock containing, besides its talc and chrysotile, quartz, and some little hornblende fragments. A quarry in serpentine near Mr. Morrell's house dips N. 20° W–78°.

The boundary of the serpentine across a small branch of Gulf Creek is a heavy bedded hornblendic gneiss dipping N. 15° W.–87°.

This illustrates the great variations in composition and posture of these serpentinous layers, and also their proximate agreement in this latter particular with the neighboring strata.

Passing by the second ("inconspicuous") deposit to the west we come to a finely exposed quarry on a hill but a couple of hundred feet from Mr. Rand's house.

* Dr. T. Sterry Hunt has invented, and Principal Dawson, in his recent address before the meeting of the A. A. A. S., at Minneapolis, has employed a new word—"metasomatosis," to replace the old and well-established word, "metasomatism." The advantage of the substitution may be doubted.

Here the northwesterly portion of the deposit dips S. 20° E.–54° though the planes taken for bedding are very much waved and contorted. The southeastern part of the exposure appears to dip N. 30° E–85. The region of the quarry where these diverse planes seem nearly to join is marked by doubtful indications of structure. If there be any foundation for these observations, this would appear to be a synclinal of canoe shape viewed here close to its S. W. end. The thickness of rock dipping S. 10° E appears to be greater than that dipping N 30° E. [A specimen of a lenticular mass (possibly pseudomorph) of green in white serpentine was found here, the interior of the former being transformed into chrysotile.]

These observations seem to show how a continuous structure connecting the detached outcrops might be compatible with a difference of strike from that of the country rock.

Of minor outcrops in Easttown, one, he says, "with a strike of S. 40° W. dips about 75° or 80° S." (sic.)

Passing by the fifth, of which he says the strike is indistinct, and coming to the sixth, "S. W. of (old) Eagle station," thick beds of serpentine are visible, very much waved, dipping E. 30° S.–55° to 60°.

The strike seems to average throughout the quarry ± N. 30° E. There is no indication of either anticlinal or synclinal here, but the rock is talcose schist with a strong resemblance to chloritic character.

The ninth is about a mile south of Berwyn station, near John Ivister's house. The signs of this outcrop are wanting on the road but the opening is seen in a field about 100 feet east of it, and just north of certain indications of trap which can be seen there.

The schistose character of the deposit is indubitable. There are three or four bands of well defined schists bounding the serpentine on the north and on the south and occurring in several lines between these two.

The average dip of the talc schist and serpentine from a number of observations is E. 40° S.–88°. About ten feet north of the excavation a very chloritic-looking schist strikes N. 40° E. Here again the general resemblance to the chloritic schists in habit and the waving character of the beds are prominent features.

To sum up, therefore, it seems to be unnecessary to suppose a strike of the serpentine differing from the general strike of the rocks adjacent to it or from the trend of the detached outcrops, provided that the almost universal waving of the outcrops of the schists generally; and

provided that a number of lines of serpentine in the serpentine belt be conceded.

The evidence in favor of the alteration of nacrites, and chloritic rocks into these talc schists and serpentine with their accompanying minerals is partly geographical, partly stratigraphical and partly chemical. As to the first, it is undeniable that directly north of the serpentine numbered "9" by Mr. Rand the hydro-mica schists of the south valley come in and extend to the valley. Though they are not found in place near the serpentine, the aspect of the fragments is much like that of the fragments of the schistose boundaries and partings of the Ivister quarry. As to the stratigraphical side of the case the nacrites show the same meandering strike lines, where exposed, that one sees here in the serpentine; and point directly towards the latter from nearly west and east of this outcrop.* Chemically the large amount of magnesia which these beds contain renders their transition easy to accept especially as innumerable cases of such transitions are well known elsewhere.

To Mr. Rand's implied question, therefore, whether the echelon structure be admitted, I am constrained to answer in the negative according to my present light, though I am open to demonstration and shall be pleased to be convinced.

It should be said in conclusion that if time had been accorded it was the writer's intention to finish the geological map of Chester county by an attempt to differentiate the component parts of what is colored as "Eozoic." A large but not nearly large enough amount of information had been collected to this end, but the demand for a completed map with the minimum delay led to the adoption of the plan which assigned a single color to all the pre-Potsdam series.

Philadelphia, Sept. 20, 1883. PERSIFOR FRAZER.

Preservation of Vulcanized Rubber.—W. Hempel, a German chemist, recommends keeping articles of vulcanized rubber in an atmosphere of petroleum. When tubes, stoppers, or other vulcanized articles are hardened, he states that they may be made pliable by exposing them in an atmosphere of carbon bisulphide.—*Les Mondes*, December 30, 1882. C.

* It must be admitted that if this waving of the outcrop consists in a variation of strike between E. and N. 30° E., there are instances of serpentine with many intermediate strikes and both the above, in the interval between Radnor and the Paoli. If it were not for this fact it would be difficult to account for the occurrence of Serpentine only in those parts of the measures where the latter strike prevailed.

A PLEA FOR PURE SCIENCE.*

By Prof. H. A. Rowland.

[An address delivered before Section B (Physics), American Association for the Advancement of Science. Minneapolis, 1883.]

The question is sometimes asked us as to the time of year we like the best. To my mind, the spring is the most delightful; for nature then recovers from the apathy of winter, and stirs herself to renewed life. The leaves grow, and the buds open, with a suggestion of vigor delightful to behold; and we revel in this ever-renewed life of nature. But this cannot always last. The leaves reach their limit; the buds open to the full, and pass away. Then we begin to ask ourselves whether all this display has been in vain, or whether it has led to a bountiful harvest.

So this magnificent country of ours has rivalled the vigor of spring in its growth. Forests have been levelled, and cities built, and a large and powerful nation has been created on the face of the earth. We are proud of our advancement. We are proud of such cities as this, founded in a day upon a spot over which, but a few years since, the red man hunted the buffalo. But we must remember that this is only the spring of our country. Our glance must not be backward; for however beautiful leaves and blossoms are, and however marvellous their rapid increase, they are but leaves and blossoms after all. Rather should we look forward to discover what will be the outcome of all this, and what the chance of harvest. For if we do this in time, we may discover the worm which threatens the ripe fruit, or the barren spot where the harvest is withering for want of water.

I am required to address the so-called physical section of this association. Fain would I speak pleasant words to you on this subject; fain would I recount to you the progress made in this subject by my countrymen, and their noble efforts to understand the order of the universe. But I go out to gather the grain ripe to the harvest, and I find only tares. Here and then a noble head of grain rises above the weeds; but so few are they, that I find the majority of my countrymen know them not, but think that they have a waving harvest, while

* In using the word "science," I refer to physical science, as I know nothing of natural science. Probably my remarks will, however, apply to both, but I do not know.

it is only one of weeds after all. American science is a thing of the future, and not of the present or past; and the proper course of one in my position is to consider what must be done to create a science of physics in this country, rather than to call telegraphs, electric lights, and such conveniences, by the name of science. I do not wish to underrate the value of all these things: the progress of the world depends on them, and he is to be honored who cultivates them successfully. So also the cook who invents a new and palatable dish for the table benefits the world to a certain degree; yet we do not dignify him by the name of a chemist. And yet it is not an uncommon thing, especially in American newspapers, to have the *applications* of science confounded with pure science; and some obscure American who steals the ideas of some great mind of the past, and enriches himself by the application of the same to domestic uses, is often lauded above the great originator of the idea, who might have worked out hundreds of such applications, had his mind possessed the necessary element of vulgarity. I have often been asked, which was the more important to the world, pure or applied science. To have the applications of a science, the science itself must exist. Should we stop its progress, and attend only to its applications, we should soon degenerate into a people like the Chinese, who have made no progress for generations, because they have been satisfied with the applications of science, and have never sought for reasons in what they have done. The reasons constitute pure science. They have known the application of gunpowder for centuries; and yet the reasons for its peculiar action, if sought in the proper manner, would have developed the science of chemistry, and even of physics, with all their numerous applications. By contenting themselves with the fact that gunpowder will explode, and seeking no farther, they have fallen behind in the progress of the world; and we now regard this oldest and most numerous of nations as only barbarians. And yet our own country is in the same state. But we have done better; for we have taken the science of the Old World, and applied it to all our uses, accepting it like the rain of heaven, without asking whence it came, or even acknowledging the debt of gratitude we owe to the great and unselfish workers who have given it to us. And, like the rain of heaven, this pure science has fallen upon our country, and made it great and rich and strong.

To a civilized nation of the present day, the applications of science are a necessity; and our country has hitherto succeeded in this line,

only for the reason that there are certain countries in the world where pure science has been and is cultivated, and where the study of nature is considered a noble pursuit. But such countries are rare, and those who wish to pursue pure science in our own country must be prepared to face public opinion in a manner which requires much moral courage. They must be prepared to be looked down upon by every successful inventor whose shallow mind imagines that the only pursuit of mankind is wealth, and that he who obtains most has best succeeded in this world. Everybody can comprehend a million of money; but how few can comprehend any advance in scientific theory, especially in its more abstruse portions! And this, I believe, is one of the causes of the small number of persons who have ever devoted themselves to work of the higher order in any human pursuit. Man is a gregarious animal, and depends very much, for his happiness, on the sympathy of those around him; and it is rare to find one with the courage to pursue his own ideals in spite of his surroundings. In times past, men were more isolated than at present, and each came in contact with a fewer number of people. Hence that time constitutes the period when the great sculptures, paintings and poems were produced. Each man's mind was comparatively free to follow its own ideals, and the results were the great and unique works of the ancient masters. To-day the railroad and the telegraph, the books and the newspapers, have united each individual man with the rest of the world: instead of his mind being an individual, a thing apart by itself, and unique, it has become so influenced by the outer world, and so dependent upon it, that it has lost its originality to a great extent. The man who in times past would naturally have been in the lowest depths of poverty, mentally and physically, to-day measures tape behind a counter, and with lordly air advises the naturally born genius how he may best bring his outward appearance down to a level with his own. A new idea he never had, but he can at least cover his mental nakedness with ideas imbibed from others. So the genius of the past soon perceives that his higher ideas are too high to be appreciated by the world; his mind is clipped down to the standard form; every natural offshoot upwards is repressed, until the man is no higher than his fellows. Hence the world, through the abundance of its intercourse, is reduced to a level. What was formerly a grand and magnificent landscape, with mountains ascending above the clouds, and depths whose gloom we cannot now appreciate, has become serene and peaceful. The depths have been filled, and the

heights levelled, and the wavy harvests and smoky factories cover the landscape.

As far as the average man is concerned, the change is for the better. The average life of man is far pleasanter, and his mental condition better, than before. But we miss the vigor imparted by the mountains. We are tired of mediocrity, the curse of our country. We are tired of seeing our artists reduced to hirelings, and imploring Congress to protect them against foreign competition. We are tired of seeing our countrymen take their science from abroad, and boast that they here convert it into wealth. We are tired of seeing our professors degrading their chairs by the pursuit of applied science instead of pure science; or sitting inactive while the whole world is open to investigation; lingering by the wayside while the problem of the universe remains unsolved. We wish for something higher and nobler in this country of mediocrity, for a mountain to relieve the landscape of its monotony. We are surrounded with mysteries, and have been created with minds to enjoy and reason to aid in the unfolding of such mysteries. Nature calls to us to study her, and our better feelings urge us in the same direction.

For generations there have been some few students of science who have esteemed the study of nature the most noble of pursuits. Some have been wealthy, and some poor; but they have all had one thing in common—the love of nature and its laws. To these few men the world owes all the progress due to applied science, and yet very few ever received any payment in this world for their labors.

Faraday, the great discoverer of the principle on which all machines for electric lighting, electric railways, and the transmission of power, must rest, died a poor man, although others and the whole world have been enriched by his discoveries. And such must be the fate of the followers in his footsteps for some time to come.

But there will be those in the future who will study nature from pure love, and for them higher prizes than any yet obtained are waiting. We have but yet commenced our pursuit of science, and stand upon the threshold wondering what there is within. We explain the motion of the planet by the law of gravitation; but who will explain how two bodies, millions of miles apart, tend to go toward each other with a certain force?

We now weigh and measure electricity and electric currents with as much ease as ordinary matter, yet have we made any approach to an

explanation of the phenomenon of electricity? Light is an undulatory motion, and yet do we know what it is that undulates? Heat is motion, yet do we know what it is that moves? Ordinary matter is a common substance, and yet who shall fathom the mystery of its internal constitution?

There is room for all in the work, and the race has but commenced. The problems are not to be solved in a moment, but need the best work of the best minds, for an indefinite time.

Shall our country be contented to stand by, while other countries lead in the race? Shall we always grovel in the dust, and pick up the crumbs which fall from the rich man's table, consisting ourselves richer than he because we have more crumbs, while we forget that he has the cake, which is the source of all crumbs? Shall we be swine, to whom the corn and husks are of more value than the pearls? If I read aright the signs of the times, I think we shall not always be contented with our inferior position. From looking down we have almost become blind, but may recover. In a new country the necessities of life must be attended to first. The curse of Adam is upon us all, and we must earn our bread.

But it is the mission of applied science to render this easier for the whole world. There is a story which I once read, which will illustrate the true position of applied science in the world. A boy, more fond of reading than of work, was employed, in the early days of the steam-engine, to turn the valve at every stroke. Necessity was the mother of invention in his case: his reading was disturbed by his work, and he soon discovered that he might become free from his work by so tying the valve to some movable portion of the engine, as to make it move its own valve. So I consider that the true pursuit of mankind is intellectual. The scientific study of nature in all its branches, of mathematics, of mankind in its past and present, the pursuit of art, and the cultivation of all that is great and noble in the world—these are the highest occupation of mankind. Commerce, the applications of science, the accumulation of wealth, are necessities which are a curse to those with high ideals, but a blessing to that portion of the world which has neither the ability nor the taste for higher pursuits.

As the applications of science multiply, living becomes easier, the wealth necessary for the purchase of apparatus can better be obtained, and the pursuit of other things besides the necessities of life becomes possible.

But the moral qualities must also be cultivated in proportion to the wealth of the country, before much can be done in pure science. The successful sculptor or painter naturally attains to wealth through the legitimate work of his profession. The novelist, the poet, the musician, all have wealth before them as the end of a successful career. But the scientist and the mathematician have no such incentive to work: they must earn their living by other pursuits, usually teaching, and only devote their surplus time to the true pursuit of their science. And frequently, by the small salary which they receive, by the lack of instrumental and literary facilities by the mental atmosphere in which they exist, and most of all, by their low ideals of life, they are led to devote their surplus time to applied science or to other means of increasing their fortune. How shall we, then, honor the few, the very few, who, in in spite of all difficulties, have kept their eyes fixed on the goal, and have steadily worked for pure science, giving to the world a most precious donation, which has borne fruit in our greater knowledge of the universe and in the applications to our physical life which have enriched thousands and benefitted each one of us? There are also those who have every facility for the pursuit of science, who have an ample salary and every appliance for works, yet who devote themselves to commercial work, to testifying in courts of law, and to any other work to increase their present large income. Such men would be respectable if they gave up the name of professor, and took that of consulting chemists or physicists. And such men are needed in the community. But for a man to occupy the professor's chair in a prominent college, and, by his energy and ability in the commercial applications of his science, stand before the local community in a prominent manner, and become the newspaper exponent of his science, is a disgrace both to him and his college. It is the death-blow to science in that region. Call him by his proper name, and he becomes at once a useful member of the community. Put in his place a man who shall by precept and example cultivate his science, and how different is the result! Young men, looking forward into the world for something to do, see before them this high and noble life, and they see that there is something more honorable than the accumulation of wealth. They are thus led to devote their lives to similar pursuits, and they honor the professor who has drawn them to something higher than they might otherwise have aspired to reach.

I do not wish to be misunderstood in this matter. It is no disgrace

to make money by an invention, or otherwise, or to do commercial scientific work under some circumstances. But let pure science be the aim of those in the chairs of professors, and so prominently the aim that there can be no mistake. If our aim in life is wealth, let us honestly engage in commercial pursuits, and compete with others for its possession. But if we choose a life which we consider higher, let us live up to it, taking wealth or poverty as it may chance to come to us, but letting neither turn us aside from our pursuit.

The work or teaching may absorb the energies of many; and, indeed, this is the excuse given by most for not doing any scientific work. But there is an old saying, that where there is a will there is a way. Few professors do as much teaching or lecturing as the German professors, who are also noted for their elaborate papers in the scientific journals. I myself have been burdened down with work, and know what it is; and yet I here assert that all *can* find time for scientific research if they desire it. But here again, that curse of our country, mediocrity, is upon us. Our colleges and universities seldom call for first-class men of reputation, and I have even heard the trustee of a well-known college assert that no professor should engage in research because of the time wasted! I was glad to see, soon after, by the call of a prominent scientist to that college, that the majority of the trustees did not agree with him.

That teaching is important, goes without saying. A successful teacher is to be respected; but if he does not lead his scholars to that which is the highest, is he not blameworthy? We are, then, to look to the colleges and universities of the land for most of the work in pure science which is done. Let us therefore examine these latter, and see what the prospect is.

One, whom perhaps we may here style a practical follower of Ruskin, has stated that while in this country he was variously designated by the title of captain, colonel, and professor. The story may or may not be true, but we all know enough of the customs of our countrymen not to dispute it on general principles. All men are born equal: some men are captains, colonels, and professors, and therefore all men are such. The logic is conclusive; and the same kind of logic seems to have been applied to our schools, colleges, and universities. I have before me the report of the commissioner of education for 1880. According to that report, there were 389,* or say, in round numbers,

* 364 reported on, and 25 not reported.

400 institutions, calling themselves colleges or universities, in our country! We may well exclaim that ours is a great country, having more than the whole world beside. The fact is sufficient. The whole earth would hardly support such a number of first-class institutions. The curse of mediocrity must be upon them, to swarm in such numbers. They must be a cloud of mosquitoes, instead of eagles as they profess. And this becomes evident on further analysis. About one-third aspire to the name of university; and I note one called by that name which has two professors and 18 students, and another having three teachers and 12 students! And these instances are not unique, for the number of small institutions and schools which call themselves universities is very great. It is difficult to decide from the statistics alone the exact standing of these institutions. The extremes are easy to manage. Who can doubt that an institution with over 800 students, and a faculty of 70, is of a higher grade than those above cited having 10 or 20 students and two or three in the faculty? Yet this is not always true; for I note one institution with over 500 students which is known to me personally as of the grade of a high school. The statistics are more or less defective, and it would much weaken the force of my remarks if I went too much into detail. I append the following tables, however, of 330 so-called colleges and universities:

218	had	from	0	to	100	students.
88	"	"	100	"	200	"
12	"	"	200	"	300	"
6	"	"	300	"	500	"
6	over		500			

Of 322 so-called colleges and universities:

206	had	0	to 10	in the	faculty.
99	"	10	" 20	"	"
17	"	20	or over	"	"

If the statistics were forthcoming—and possibly they may exist—we might also get an idea of the standing of these institutions and their approach to the true university idea, by the average age of the scholars. Possibly also the ratio of number of scholars to teachers might be of some help. All these methods give an approximation to the present standing of the institutions. But there is another method of attacking the problem, which is very exact, but it only gives us the *possibilities* of which the institution is capable. I refer to the wealth of the institution. In

estimating the wealth, I have not included the value of grounds and buildings, for this is of little importance, either to the present or future standing of the institution. As good work can be done in a hovel as in a palace. I have taken the productive funds of the institution as the basis of estimate. I find:

234 have below $500,000.
8 " between $500,000 and $1,000,000.
8 " over $1,000,000.

There is no fact more firmly established, all over the world, than that the higher education can never be made to pay for itself. Usually the cost to a college, of educating a young man, very much exceeds what he pays for it, and is often three or four times as much. The higher the education, the greater this proportion will be; and a university of the highest class should anticipate only a small accession to its income from the fees of students. Hence the test I have applied must give a true representation of the possibilities in every case. According to the figures, only 16 colleges and universities have $500,000 or over of invested funds, and only one-half of these have $1,000,000 and over. Now, even the latter sum is a very small endowment for a college; and to call any institution a university which has less than $1,000,000, is to render it absurd in the face of the world. And yet more than 100 of our institutions, many of them very respectable colleges, have abused the word "university" in this manner. It is to be hoped that the endowment of the more respectable of these institutions may be increased, as many of them deserve it; and their unfortunate appellation has probably been repented of long since.

But what shall we think of a community that gives the charter of a university to an institution with a total of $20,000 endowment, two so-called professors, and 18 students? or another with three professors, 12 students, and a total of $27,000 endowment, mostly invested in buildings! And yet there are very many similar institutions; there being 16 with three professors or less, and very many indeed with only four or five.

Such facts as these could only exist in a democratic country, where pride is taken in reducing everything to a level. And I may also say that it can only exist in the early days of such a democracy; for an intelligent public will soon perceive that calling a thing by a wrong name does not change its character, and that truth, above all things, should be taught to the youth of the nation.

It may be urged, that all these institutions are doing good work in education; and that many young men are thus taught, who could not afford to go to a true college or university. But I do not object to the education,—though I have no doubt an investigation would disclose equal absurdities here,—for it is aside from my object. But I do object to lowering the ideals of the youth of the country. Let them know that they are attending a school, and not a university; and let them know that above them comes the college, and above that the university. Let them be taught that they are only half educated, and that there are persons in the world by whose side they are but atoms. In other words, let them be taught the truth.

It may be that some small institutions are of high grade, especially those which are new; but who can doubt that more than two-thirds of our institutions calling themselves colleges and universities are unworthy of the name? Each one of these institutions has so-called professors, but it is evident that they can be only of the grade of teachers. Why should they not be so called? The position of teacher is an honored one, but is not made more honorable by the assumption of a false title. Furthermore, the multiplication of the title, and the ease with which it can be obtained, render it scarcely worth striving for. When the man of energy, ability, and perhaps genius is rewarded by the same title and emoluments as the commonplace man with the modicum of knowledge, who takes to teaching, not because of any aptitude for his work, but possibly because he has not the energy to compete with his fellow-men in business, then I say one of the inducements for first-class men to become professors is gone.

When work and ability are required for the position, and when the professor is expected to keep up with the progress of his subject, and to do all in his power to advance it, and when he is selected for these reasons, then the position will be worth working for, and the successful competitor will be honored accordingly. The chivalric spirit which prompted Faraday to devote his life to the study of nature may actuate a few noble men to give their life to scientific work; but, if we wish to cultivate this highest class of men in science, we must open a career for them worthy of their efforts,

Jenny Lind, with her beautiful voice, would have cultivated it to some extent in her native village; yet who would expect her to travel over the world, and give concerts for nothing? and how would she have been able to do if she had wished? And so the scientific man,

whatever his natural talents, must have instruments and a library, and a suitable and respectable salary to live upon, before he is able to exert himself to his full capacity. This is true of advance in all the higher departments of human learning, and yet something more is necessary. It is not those in this country who receive the largest salary, and have positions in the richest colleges, who have advanced their subject the most: men receiving the highest salaries, and occupying the professor's chair, are to-day doing absolutely nothing in pure science, but are striving by the commercial applications of their science to increase their already large salary. Such pursuits, as I have said before, are honorable in their proper place; but the duty of a professor is to advance his science, and to set an example of pure and true devotion to it which shall demonstrate to his students and the world that there is something high and noble worth living for. Money-changers are often respectable men, and yet they were once severely rebuked for carrying on their trade in the court of the temple.

Wealth does not constitute a university, buildings do not: it is the men who constitute its faculty, and the students who learn from them. It is the last and highest step which the mere student takes. He goes forth into the world, and the height to which he rises has been influenced by the ideals which he has consciously or unconsciously imbibed in his university. If the professors under whom he has studied have been high in their profession, and have themselves had high ideals; if they have considered the advance of their particular subject their highest work in life, and are themselves honored for their intellect throughout the world,—the student is drawn toward that which is highest, and ever after in life has high ideals. But if the student is taught by what are sometimes called good teachers, and teachers only, who know little more than the student, and who are often surpassed and even despised by him, no one can doubt the lowered tone of his mind. He finds that by his feeble efforts he can surpass one to whom a university has given its highest honor; and he begins to think that he himself is a born genius, and the incentive to work is gone. He is great by the side of the molehill, and does not know any mountain to compare himself with.

A university should not only have great mon in its faculty, but have numerous minor professors and assistants of all kinds, and should encourage the highest work, if for no other reason than to encourage the student to his highest efforts.

But, assuming that the professor has high ideals, wealth such as only a large and high university can command is necessary to allow him the fullest development.

And this is specially so in our science of physics. In the early days of physics and chemistry, many of the fundamental experiments could be performed with the simplest apparatus. And so we often find the names of Wollaston and Faraday mentioned as needing scarcely anything for their researches. Much can even now be done with the simplest apparatus; and nobody, except the utterly incompetent, need stop for want of it. But the fact remains, that one can only be free to investigate in all departments of chemistry and physics, when he not only has a complete laboratory at his command, but a friend to draw on for the expenses of each experiment. That simplest of the departments of physics, namely, astronomy, has now reached such perfection that nobody can expect to do much more in it without a perfectly equipped observatory; and even this would be useless without an income sufficient to employ a corps of assistants to make the observations and computations. But even in this simplest of physical subjects, there is great misunderstanding. Our country has very many excellent observatories: and yet little work is done in comparison, because no provision has been made for maintaining the work of the observatory; and the wealth which, if concentrated, might have made one effective observatory which would prove a benefit to astronomical science, when scattered among a half-dozen, merely furnishes telescopes for the people in the surrounding region to view the moon with. And here I strike the keynote of at least one need of our country, if she would stand well in science; and the following item which I clip from a newspaper will illustrate the matter:

"The eccentric old Canadian, Arunah Huntington, who left $200,000 to be divided among the public schools of Vermont, has done something which will be of little practical value to the schools. Each district will be entitled to the insignificant sum of $10, which will not advance much the cause of education."

Nobody will dispute the folly of such a bequest, or the folly of filling the country with telescopes to look at the moon, and calling them observatories. How much better to concentrate the wealth into a few parcels, and make first-class observatories and institutions with it!

Is it possible that any of our four hundred colleges and universities have love enough of learning to unite with each other and form larger

institutions? Is it possible that any have such a love of truth that they are willing to be called by their right name? I fear not; for the spirit of expectation, which is analogous to the spirit of gambling, is strong in the American breast, and each institution which now, except in name, slumbers in obscurity, expects in time to bloom out into full prosperity. Although many of them are under religious influence, where truth is inculcated, and where men are taught to take a low seat at the table in order that they may be honored by being called up higher, and not dishonored by being thrust down lower, yet these institutions have thrust themselves into the highest seats, and cannot probably be dislodged.

But would it not be possible to so change public opinion that no college could be founded with a less endowment than say $1,000,000, or no university with less than three or four times that amount? From the report of the Commissioner of Education, I learn that such a change is taking place; that the tendency towards large institutions is increasing, and that it is principally in the west and southwest that the multiplication of small institutions with big names is to be feared most, and that the east is almost ready for the great coming university.

The total wealth of the four hundred colleges and universities in 1880 was about $40,000,000 in buildings, and $43,000,000 in productive funds. This would be sufficient for one great university of $10,000,000, four of $5,000,000, and twenty-six colleges of $2,000,000 each. But such an idea can of course never be carried out. Government appropriations are out of the question, because no political trickery must be allowed around the ideal institution.

In the year 1880 the private bequests to all schools and colleges amounted to about $5,500,000; and, although there was one bequest of $1,250,000, yet the amount does not appear to be phenomenal. It would thus seem that the total amount was about five million dollars in one year, of which more than half is given to so-called colleges and universities. It would be very difficult to regulate these bequests so that they might be concentrated sufficiently to produce an immediate result. But the figures show that generosity is a prominent feature of the American people, and that the needs of the country only have to be appreciated to have the funds forthcoming. We must make the need of research and of pure science felt in the country. We must live such lives of pure devotion to our science, that all shall see that we ask for money, not that we may live in indolent ease at the expense of charity,

but that we may work for that which has advanced and will advance the world more than any other subject, both intellectually and physically. We must live such lives as to neutralize the influence of those who in high places have degraded their profession, or have given themselves over to ease, and do nothing for the science which they represent. Let us do what we can with the present means at our disposal. There is not one of us who is situated in the position best adapted to bring out all his powers, and to allow him to do most for his science. All have their difficulties, and I do not think that circumstances will ever radically change a man. If a man has the instinct of research in him, it will always show itself in some form. But circumstances may direct it into new paths, or may foster it so that what would otherwise have died as a bud now blossoms and ripens into the perfect fruit.

Americans have shown no lack of invention in small things; and the same spirit, when united to knowledge and love of science, becomes the spirit of research. The telegraph operator, with his limited knowledge of electricity and its laws, naturally turns his attention to the improvement of the only electrical instrument he knows anything about; and his researches would be confined to the limited sphere of his knowledge, and to the simple laws with which he is acquainted. But as his knowledge increases, and the field broadens before him, as he studies the mathematical theory of the subject, and the electro-magnetic theory of light loses the dim haze due to distance, and becomes his constant companion, the telegraph instrument becomes to him a toy, and his effort to discover something new becomes research in pure science.

It is useless to attempt to advance science until one has mastered the science; he must step to the front before his blows can tell in the strife. Furthermore, I do not believe anybody can be thorough in any department of science, without wishing to advance it. In the study of what is known, in the reading of the scientific journals, and the discussions therein contained of the current scientific questions, one would obtain an impulse to work, even though it did not before exist. And the same spirit which prompted him to seek what was already known, would make him wish to know the unknown. And I may say that I never met a case of thorough knowledge in my own science, except in the case of well-known investigators. I have met men who talked well, and I have sometimes asked myself why they did not do something; but further knowledge of their character has shown me the

superficialty of their knowledge. I am no longer a believer in men who could do something if they would, or would do something if they had a chance. They are imposters. If the true spirit is there, it will show itself in spite of circumstances.

As I remarked before, the investigator in pure science is usually a professor. He must teach as well as investigate. It is a question which has been discussed in late years, as to whether these two functions would better be combined in the same individual, or separated. It seems to be the opinion of most, that a certain amount of teaching is conducive, rather than otherwise, to the spirit of research. I myself think that this is true, and I should myself not like to give up my daily lecture. But one must not be overburdened. I suppose that the true solution, in many cases, would be found in the multiplication of assistants, not only for the work of teaching, but of research. Some men are gifted with more ideas than they can work out with their own hands, and the world is losing much by not supplying them with extra hands. Life is short; old age comes quickly, and the amount one pair of hands can do is very limited. What sort of shop would that be, or what sort of factory, where one man had to do all the work with his own hands? It is a fact in nature, which no democracy can change, than men are *not* equal—that some have brains, and some hands. And no idle talk about equality can ever subvert the order of the universe.

I know of no institution in this country where assistants are supplied to aid directly in research. Yet why should it not be so? And even the absence of assistant professors and assistants of all kinds, to aid in teaching, is very noticeable, and must be remedied before we can expect much.

There are many physical problems, especially those requiring exact measurements, which cannot be carried out by one man, and can only be successfully attacked by the most elaborate apparatus, and with a full corps of assistants. Such are Regnault's experiments on the fundamental laws of gases and vapors, made thirty or forty years ago by aid from the French government, and which are the standards to this day. Although these experiments were made with a view to the practical calculation of the steam-engine, yet they were carried out in such a broad spirit that they have been of the greatest theoretical use. Again, what would astronomy have done without the endowments of observatories? By their means, that science has become the most perfect of all branches of physics, as it should be from its simplicity.

There is no doubt, in my mind, that similar institutions for other branches of physics, or, better, to include the whole of physics, would be equally successful. A large and perfectly equipped physical laboratory with its large revenues, its corps of professors and assistants, and its machine-shop for the construction of new apparatus, would be able to advance our science quite as much as endowed observatories have astronomy. But such a laboratory should not be founded rashly. The value will depend entirely on the physicist at its head, who has to devise the plan, and to start it into practical working. Such a man will always be rare, and cannot always be obtained. After one had been successfully started, others could follow; for imitation requires little brains.

One could not be certain of getting the proper man every time, but the means of appointment should be most carefully studied so as to secure a good average. There can be no doubt that the appointment should rest with a scientific body capable of judging the highest work of each candidate.

Should any popular element enter, the person chosen would be either of the literary-scientific order, or the dabbler on the outskirts who presents his small discoveries in the most theatrical manner. What is required is a man of depth, who has such an insight into physical science that he can tell when blows will best tell for its advancement.

Such a grand laboratory as I describe does not exist in the world, at present, for the study of physics. But no trouble has ever been found in obtaining means to endow astronomical science. Everybody can appreciate, to some extent, the value of an observatory; as astronomy is the simplest of scientific subjects, and has very quickly reached a position where elaborate instruments and costly computations are necessary to further advance. The whole domain of physics is so wide that workers have hitherto found enough to do. But it cannot always be so, and the time has even now arrived when such a grand laboratory should be founded. Shall our country take the lead in this matter, or shall we wait for foreign countries to go before? They will be built in the future, but when and how is the question.

Several institutions are now putting up laboratories for physics. They are mostly for teaching, and we can expect only a comparatively small amount of work from most of them. But they show progress; and, if the progress be as quick in this direction as in others, we should be able to see a great change before the end of our lives.

As stated before, men are influenced by the sympathy of those with whom they come in contact. It is impossible to immediately change public opinion in our favor; and, indeed, we must always seek to lead it, and not be guided by it. For pure science is the pioneer who must not hover about cities and civilized countries, but must strike into unknown forests, and climb the hitherto inaccessible mountains which lead to and command a view of the promised land,—the land which science promises us in the future; which shall not only flow with milk and honey, but shall give us a better and more glorious idea of this wonderful universe. We must create a public opinion in our favor, but it need not at first be the general public. We must be contented to stand aside, and see the honors of the world for a time given to our inferiors; and must be better contented with the approval of our own consciences, and of the very few who are capable of judging our work, than of the whole world beside. Let us look to the other physicists, not in our own town, not in our own country, but in the whole world, for the words of praise which are to encourage us, or the words of blame which are to stimulate us to renewed effort. For what to us is the praise of the ignorant? Let us join together in the bonds of our scientific societies, and encourage each other, as we are now doing, in the pursuit of our favorite study; knowing that the world will some time recognize our services, and knowing, also, that we constitute the most important element in human progress.

But danger is also near, even in our societies. When the average tone of the societies is low, when the highest honor are given to the mediocre, when third-class men are held up as examples, and when trifling inventions are magnified into scientific discoveries, then the influence of such societies is prejudicial. A young scientist attending the meetings of such a society soon gets perverted ideas. To his mind, a molehill is a mountain, and the mountain a molehill. The small inventor or the local celebrity rises to a greater height, in his mind, than the great leader of science in some foreign land. He gauges himself by the molehill, and is satisfied with his stature; not knowing that he is but an atom in comparison with the mountain, until, perhaps, in old age, when it is too late. But, if the size of the mountain had been seen at first, the young scientist would at least have been stimulated in his endeavor to grow.

We cannot all be men of genius; but we can, at least, point them out to those around us. We may not be able to benefit science much

ourselves; but we can have high ideals on the subject, and instil them into those with whom we come in contact. For the good of ourselves, for the good of our country, for the good to the world, it is incumbent on us to form a true estimate of the worth and standing of persons and things, and to set before our own minds all that is great and good and noble, all that is most important for scientific advance, above the mean and low and unimportant.

It is very often said, that a man has a right to his opinion. This might be true for a man on a desert island, whose error would influence only himself. But when he opens his lips to instruct others, or even when he signifies his opinions by his daily life, then he is directly responsible for all his errors of judgment or fact. He has no right to think a molehill as big as a mountain, nor to teach it, any more than he has to think the world flat, and teach that it is so. The facts and laws of our science have *not* equal importance, neither have the men who cultivate the science achieved equal results. One thing is greater than another, and we have no right to neglect the order. Thus shall our minds be guided aright, and our efforts be toward that which is the highest.

Then shall we see that no physicist of the first class has ever existed in this country, that we must look to other countries for our leaders in that subject, and that the few excellent workers in our country must receive many accessions from without before they can constitute an American science, or do their share in the world's work.

But let me return to the subject of scientific societies. Here American science has its hardest problem to contend with. There are very many local societies dignified by high-sounding names, each having its local celebrity, to whom the privilege of describing some crab with an extra claw, which he found in his morning ramble, is inestimable. And there are some academies of science, situated at our seats of learning, which are doing good work in their locality. But distances are so great that it is difficult to collect men together at any one point. The American association, which we are now attending, is not a scientific academy, and does not profess to be more than a gathering of all who are interested in science, to read papers and enjoy social intercourse. The National academy of sciences contains eminent men from the whole country, but then it is only for the purpose of advising the government freely on scientific matters. It has no building, it has no library; and it publishes nothing except the information which it freely gives to the

government, which does nothing for it in return. It has not had much effect directly on American science; but the liberality of the government in the way of scientific expeditions, publications, etc., is at least partly due to its influence, and in this way it has done much good. But it in no way takes the place of the great Royal society, or the great academies of science at Paris, Berlin, Vienna, St. Petersburg, Munich, and, indeed, all the European capitals and large cities. These, by their publications, give to the young student, as well as the more advanced physicist, models of all that is considered excellent; and to become a member is one of the highest honors to which he can aspire, while to write a memoir which the academy considers worthy to be published in its transactions excites each one to his highest effort.

The American academy of sciences in Boston is perhaps our nearest representation of this class of academies, but its limitation of membership to the State deprives it of its national character.

But there is another matter which influences the growth of our science.

As it is necessary for us still to look abroad for our highest inspiration in pure science, and as science is not an affair of one town or one country, but of the whole world, it becomes us all to read the current journals of science and the great transactions of foreign societies, as well as those of our own countries. These great transactions and journals should be in the library of every institution of learning in the country, where science is taught. How can teachers and professors be expected to know what has been discovered in the past, or is being discovered now, if these are not provided? Has any institution a right to mentally starve the teachers whom it employs, or the students who come to it? There can be but one answer to this; and an institution calling itself a university, and not having the current scientific journals upon its table or the transactions of societies upon its library-shelves, is certainly not doing its best to cultivate all that is best in this world.

We call this a free country, and yet it is the only one where there is a direct tax upon the pursuit of science. The low state of pure science in our country may possibly be attributed to the youth of the country; but direct tax, to prevent the growth of our country in that subject, cannot be looked upon as other than a deep disgrace. I refer to the duty upon foreign books and periodicals. In our science, no books above elementary ones have ever been published, or are likely to be published, in this country; and yet every teacher in physics must have

them, not only in the college library, but on his own shelves, and must pay the government of this country to allow him to use a portion of his small salary to buy that which is to do good to the whole country. All freedom of intercourse which is necessary to foster our growing science is thus broken off; and that which might, in time, relieve our country of its mediocrity, is nipped in the bud by our government, which is most liberal when appealed to directly on scientific subjects.

One would think that books in foreign languages might be admitted free; but to please the half-dozen or so workmen who reprint German books, not scientific, our free intercourse with that country is cut off. Our scientific associations and societies must make themselves heard in this matter, and show those in authority how the matter stands.

In conclusion, let me say once more, that I do not believe that our country is to remain long in its present position. The science of physics, in whose applications our country glories, is to arise among us, and make us respected by the nations of the world. Such a prophecy may seem rash with regard to a nation which does not yet do enough physical work to support a physical journal. But we know the speed with which we advance in this country; we see cities springing up in a night, and other wonders performed at an unprecedented rate. And now we see physical laboratories being built, we see a great demand for thoroughly trained physicists, who have not shirked their mathematics, both as professors and in so-called practical life; and perhaps we have the feeling, common to all true Americans, that our country is going forward to a glorious future, when we shall lead the world in the strife for intellectual prizes as we now do in the strife for wealth.

But if this is to be so, we must now aim low. The problems of the universe cannot be solved without labor; they cannot be attacked without the proper intellectual as well as physical tools; and no physicist need expect to go far without his mathematics. No one expects a horse to win in a great and long race who has not been properly trained; and it would be folly to attempt to win with one, however pure his blood and high his pedigree, without it. The problems we solve are more difficult than any race: the highest intellect cannot hope to succeed without proper preparation. The great prizes are reserved for the greatest efforts of the greatest intellects, who have kept their mental eye bright and flesh hard by constant exercise. Apparatus can be bought with money, talents may come to us at birth; but our mental tools, our mathematics, our experimental ability, our knowl-

edge of what others have done before us, all have to be obtained by work. The time is almost past, even in our own country, when third-rate men can find a place as teachers, because they are unfit for everything else. We wish to see brains and learning, cnmbined with energy and immense working-power, in the professor's chair; but, above all, we wish to see that high and chivalrous spirit which causes one to pursue his idea in spite of all difficulties, to work at the problems of nature with the approval of his own conscience, and not of men before him. Let him fit himself for the struggle with all the weapons which mathematics and the experience of those gone before him can furnish, and let him enter the arena with the fixed and stern purpose to conquer. Let him not be contented to stand back with the crowd of mediocrity, but let him press forward for a front place in the strife.

The whole universe is before us to study. The greatest labor of the greatest minds has only given us a few pearls; and yet the limitless ocean, with its hidden depths filled with diamonds and precious stones, is before us. The problem of the universe is yet unsolved, and the mystery involved in one single atom yet eludes us. The field of research only opens wider and wider as we advance, and our minds are lost in wonder and astonishment at the grandeur and beauty unfolded before us. Shall we help in this grand work, or not? Shall our country do its share, or shall it still live in the almshouse of the world?

French Tribute to Darwin.—The Committee of the Royal Society has requested the men of science upon the continent to join them in erecting a monument to Darwin. The French Academy accordingly appointed a committee to receive contributions, and M. de Quatrefages, in the name of M. Milne Edwards, who was absent on account of sickness, addressed the Academy in advocacy of the subscription. He stated, however, that the French committee wished to express no sentiment in regard to the scientific or philosophical teachings of Darwin, but that their homage was rendered to a man who consecrated his whole life to scientific work, who attacked successfully some of the most difficult problems of organic life, and who, by the special direction of his investigations and the success which often crowned them, rendered brilliant service to positive science.—*Les Mondes*, January 6, 1883. C.

Book Notices.

CONVERSION TABLES OF METRIC AND BRITISH OR UNITED STATES WEIGHTS AND MEASURES; with an Introduction by Robert H. Thurston. New York: John Wiley & Sons, 1883.

Professor Thurston has given to the public in this small volume quite a complete series of tables for passing from our old standards of weights and measures to the French system, and the reverse. They are compiled in part from accepted authorities. To an engineer who habitually consults French professional literature, or to any other person who finds himself obliged occasionally to convert French into English weights and measures, or who wishes only to familiarize himself with the French system, and desires something more elaborate than is obtainable from technical pocket-books, the little treatise in question will be welcome.

An introduction by the author precedes the tables, and is a short essay, neatly and concisely written, on standards in general. The metric system is advocated in it, and allusion is made to the difficulty of fully adopting this system in Great Britain and the United States. While to a scientific man the nomenclature of the French system appears simplicity itself, to the mass of an *English-speaking* people it sounds complex and foreign, and raises their prejudices. But the nomenclature of a new system of weights and measures is really of not much consequence, provided the system is good; and by retaining familiar denominations, with the prefix *new* put before them, a great obstacle is removed to the spread of the improved system. Thus, the new yard may be the meter, the new pound the half kilogramme, the new quart the liter. The subdivisions may be either according to the decimal or duodecimal enumeration, as may be preferred in the different vocations. In respect to the inconvenience which certain industries would experience from a change of weights and measures, it is a very small offset to the aggregate advantages attainable in the rest by the adoption of the metric system. Moreover, such industries may continue using the old standards until they can adapt themselves by gradual provision to the new order of things. After all is ready for a change let it occur at once. Improvements cannot be forsworn because some will suffer by them. How many have suffered by changes which they were powerless to prevent and too blind to foresee!

Momentary pangs accompany the first steps of a revolution, which need not be violent to be real, which may affect a whole people or a small trade. This is the law of progress; this is broadly the law of nature. A powerful conservative element may hold in check for some time a real advance; but meanwhile this gathers strength, and at last bursts suddenly through all opposition. Conservatism stands up for the purpose, chiefly of being knocked down sooner or later.

Lieut. Birnie's tables, as here given by Professor Thurston, appear adapted to all the requirements of the engineer. Those of Captain Noble are not so extensive, yet may better suit certain purposes. Additional tables by the author follow. Then the C. G. S. system of units is briefly considered. Finally the work closes with a short table of four-figure logarithms. C. E.

STUDY ON RESERVOIR WALLS, by J. B. Krantz. Translated from the French, by F. A. Mahan. New York: John Wiley & Sons, 1883.

This little work merits attention from the profession. Its author, M. Krantz, is a French government engineer, who, by his abilities, ranks high in his corps. As an introduction to the study of reservoir dams of masonry it serves its purpose very well; and those engineers also who have given attention to such structures, may find suggestions in it new to them. It advocates the superiority of the French form of cross-section, which consists of a level top and *curved* batters at the sides. The latter feature will not be viewed favorably by the generality of American engineers, prejudiced as they are against all curved work; but in this instance especially, as in some others, the prejudice is unfounded. The object in using batters curving more and more decidedly toward the bottom of the dam is, to concentrate economically the mass of material in this part of the section, where it scientifically belongs. Certain objections may, indeed, be urged even here against curved batters by an engineer who well understands his art; and in a few recent French dams they have consequently been omitted, although the shapes adopted approached closely to that deduced with them. Yet they are perfectly practicable in every way. As to the trouble in forming them, it is no greater than with broken or continuous straight batters.

A number of small plates, with dimensions in full on the figures, accompany this essay. About the first half of them give standard

sections for dams of various heights; the remainder are comparisons between the standard sections and many old Spanish and French dams noted for their size and age. These comparisons are very instructive; for the old Spanish dams would to-day be repeated by so-called practical men; that is, by men who do not theorize. In the French form of section we see law, science, economy; in any of the Spanish sections we as clearly perceive uncertainty, bad disposition of mass, and enormous waste of material. The older French dams show the same defects, but not so grossly. The Furens dam in France, probably the highest as yet constructed, retaining at the deepest part a head of water of 164 feet when the reservoir is full, is built strictly upon the system advocated in this little work; and it is now sufficiently old to confirm the correctness of the principle of construction adopted C. E.

La Navigation Electrique, par Georges Dary, Paris. Librairie Polytechnique de J. Baudry, Editeur, 15 Rue des Saint-Pères, 1882, pp. 65.

This little book is very general in its title and is correspondingly particular in its subject matter, being an account of the apparatus devised by M. Gustave Trouvé for the propulsion of pleasure boats by electricity, with a brief reference to the experiments of M. de Jacobi in 1839 in St. Petersburg, and of M. de Molins twenty years later in Paris, and a suggestion of the possibilities of the use of an electrical motor for aerial navigation. The apparatus of M. Trouvé consists of a screw placed in a recess in the rudder, the motor being placed upon the rudder-head, and the steering cords being the conductors, and it can be applied to any boat by simply unshipping the ordinary rudder and substituting this one in its place.

The motor consists of a Siemens armature with some modifications, by which he claims to have increased the effective part of the revolution and correspondingly reduced the dead part; and he uses an electro-magnet instead of a permanent magnet, which motors he combines, so that two or more of them act together, while he can use one at a time for less speed when desired.

He uses a sulpho-chromic battery with some special details of construction, which, like those upon the motor, are ingeniously devised for convenience of use and economy of space. It is stated that in 1881, he made, on the Seine, an average speed of from five to six knots per hour. G. M. E.

FORMULAIRE PRATIQUE DE L'ÉLECTRICIEN; PREMIERE ANNEE, 1883. E. Hospitalier. Paris: G. Masson, 1883.

The two hundred and seventy-eight closely printed pages of this little book contain a mass of information, of so convenient and suggestive a character as fully to justify its aim to be the practical electrician's *vade mecum*. In the first of the five main divisions of the book is given a concise statement of the general laws regulating electrical and magnetic action. The second treats of the units of measurement, and also contains tables showing the mutual relations between the numerous practical units now used in electrical mechanics. The third part, with the assistance of neat illustrations, is devoted to the instruments, and methods used in measurement. The fourth contains practical directions, mathematical and physical tables, and a goodly collection of the latest experimental results in the various departments of applied electricity. The concluding part is devoted to receipts and processes of advantage in manipulation and construction.

In a work that aims to be comprehensive and yet to represent the science of the hour, there must always be found something the reader would like to see improved in form or in fact. Why, for example, should not the late values for the velocity of light by Newcomb and Michaelson be inserted along with the old French results? And so a list of minor improvements might be suggested which would add both to its scientific and international character. We prefer, however, to respond to the auhor's direct invitation to suggestion, to offer one of a more general nature. The brief description of methods, instruments, results, etc., are given with but a very few references to the publications where they were first described. While this has the advantage of brevity, an appendix of say twenty pages of references to the *original papers*, or even to more comprehensive treatises would not add much to bulk, and would, moreover, make this formulary a much more valuable book for the general student, and not less so for the practical man. In fact, with such addition, it would be difficult to find a work better suited to outline a course of instruction in the Electrical Engineering required by present science and practice. M. B. S.

ELECTRO-MAGNETS: the Determination of the Elements of their Construction; by T. H. Du Moncel (tr. from 2d ed.) Van Nostrand's Science Series, No. 64. New York: D. Van Nostrand, 1883.

The increasing importance of the electro-magnet as an industrial appliance makes this reproduction of M. Du Moncel's investigations

timely. These researches belong to that daily enlarging class whose aim is to make the mathematical laws of electrical action available in the actual construction. Those interested will here find convenient formulæ, numerically illustrated, for computing the elements of the electro-magnet, best suited to the varying conditions of practice—particularly telegraphic practice. We regret to note that the resistances are not, as a rule, given in the recognized units. M. B. S.

DYNAMO-ELECTRIC MACHINERY; a series of Lectures by Sylvanus P. Thompson, B. A.; D. Sc.; M. S. T. E. With an Introduction by Frank L. Pope, M. S. T. E. Van Nostrand's Science Series, No. 66. New York: D. Van Nostrand, 1883.

There have not been wanting, in recent years, special works describing, in a general, and sometimes, indeed, in a tediously minute manner, the various forms of dynamo machines proposed by inventors. We have, however, in these three able lectures of Prof. S. P. Thompson, an entirely novel treatment, one truly philosophic and consequently also comprehensive. Dynamos are not only classified, according to the theory of their construction, but are again arranged in classes, according with the various methods of their use. This plan, followed out in detail allows a scientific discussion of advantages and disadvantages in particular forms, as well as a clear presentation of the ideals demanded by theory.

We cannot dismiss this opportunity of calling attention to a neat mathematical discussion in the last lecture concerning the "maximum efficiency" of the dynamo as a motor. It had been shown by Siemens that the "maximum rate of doing work" does not necessarily conduce to "maximum efficiency." This point is not only analytically developed by Prof. Thompson, but the relation between the laws of Jacobi and Siemens is also illustrated geometrically. M. B. S.

Iron Watches.—Messrs. Crowther Bros. & Co., of Kidderminster, in order to prove the malleability and ductility of their iron, have constructed a watch entirely of iron, which keeps excellent time. Claudius Saunier, on reporting this fact in the *Revue Chronomètrique*, adds: There is nothing new under the sun. We have a watch upon which is engraved the date of 1504, and in which all the wheels and pinions are made of iron.—*Les Mondes*, December 30. 1882. C.

Conservation of Solar Energy.—Duflos de Senlis has addressed a letter to the *Revue Scientifique*, in which he claims that the solar heat must always have been the same as it is now. He starts from the principle that all the heat which is radiated from the sun returns to it under some form or other. The sun, in his opinion, may be compared to an incandescent electric lamp working in an absolute vacuum, and the arguments which have been adduced in favor of a gradual concentration of the sun do not appear to him to be well grounded.—*Les Mondes*, January 6, 1883. C.

Elephant's Milk.—Dr. Quesneville states that elephant's milk resembles cream, but it has not the consistency of ordinary cream. When seen in the microscope the globules are large, transparent, and sharply outlined. The cream rises rapidly, leaving the milk of a bluish tinge. The fatty matter has a yellow color, similar to that of olive oil; liquid at ordinary temperature, it solidifies at —18° (—0°4 F.). The odor and taste are very pleasant. The reporter of *Les Mondes* looks forward to the day when some bold speculator will milk elephants in the streets of Paris, in order to offer glasses of the milk to amateurs, and predicts a brilliant success to the first one who will try the experiment.—*Les Mondes*, January 6, 1883. C.

Cyclonic Theory of Sun Spots.—Faye cites Young's objections to his cyclonic theory on the ground that the velocity of solar rotation is so small that it would not be sufficient to produce a cyclone. He refers to the hydrodynamic law, that the angular velocity in a whirlwind varies in the inverse ratio of the square of the distance from the axis, and he names the following distinctive characteristics of gyratory movement, which are found upon the sun as well as in our atmosphere. 1. The circular form of all the spots when they first make their appearance. 2. The conical form of their opening. 3. The great contraction of the opening at a lower level. 4. Their tendency to enlarge while still preserving a circular form. 5. Their tendency to subdivide into partial spots, which become complete spots with a penumbra, nucleus, and dark centre. 6. Their regular movement in the direction of the current in which they originate. 7. Their long duration, which implies a gyration around a vertical axis. 8. Their mode of disappearance, which corresponds to that of whirlpools upon the face of the earth. 9. The reappearance of hydrogen around the spots, as if it had been absorbed at the centre and thrown out at the circumference.—*Comptes Rendus*, December 26, 1882. C.

Nitrogen in Soils.—J. B. Lawes, in a long communication upon agriculture, advocates the opinion that the source of all the nitrogen which is contained in crops is found in the soil itself and in the manures which are supplied. Although the experiments at Rothamsted may not yet have established this theory beyond controversy, they have given strong indications of its truth, and he thinks that future operations will demonstrate it conclusively. He regards it as fortunate for agriculture and encouraging to those who are engaged in it, that the stock of nitrogen, even in a subsoil which is comparatively poor, is so large as to show very little diminution after cultivation for a long series of years.—*Bull. de la Soc. d'Encour.*, November, 1882. C.

Propellers of Manganese Bronze.—The resistance of manganese bronze is greater than that of the best ordinary bronze or of cast steel. The wings of propellers can, therefore, be made much lighter than usual, and the resistance of the water largely reduced. Moreover, the manganese bronze comes from the mould in the exact shape which is desired, and there is no danger of change by the process of annealing, which is required for steel. In the third place, the corrosion to which steel is subject and which requires frequent renewals, is entirely avoided. The manganese bronze preserves a perfectly clean and smooth surface for an indefinite time. It is a little more expensive than ordinary bronze, but the difference in price is largely compensated by the difference of resistance, which allows the employment of a smaller amount of material. It costs about twice as much as steel, but in consideration of the frequent renewals of steel the manganese bronze is eventually cheaper. The objection that manganese bronze might produce a prejudicial galvanic action has not been sustained by any authentic observations.—*Chron. Industr.*, January 1, 1883. C.

Solar Eclipse of May, 1883.—In a report to the *Bureau des Longitudes*, M. Janssen speaks of the favorable circumstances which will attend the approaching eclipse of the sun. Among the questions which it may perhaps enable us to solve are the following: 1. Are the appendices of the cornea parts of a solar atmosphere, or are they merely swarms of meteorities circulating about the sun? 2. Is the zodiacal light due to an independent body, or is it connected with the cornea? 3. Are there planets between Mercury and the sun, and are the anticipations of Leverrier to be confirmed within the planetary belt as they were at the outer limits of the belt? There are two ways of studying

the last question—by a careful examination of the sun's surface, or by an exploration of the circumsolar regions when an eclipse renders such explorations possible. The second method seems the most efficacious when an eclipse is long enough to allow a minute examination. The eclipse of May 6th will last 5 minutes 59 seconds, which is three times the duration of ordinary eclipses. It will, therefore, present unusually favorable conditions for investigation. He recommends that the *Bureau* should send out an expedition by way of New York, crossing the American continent to San Francisco, and there taking a steam packet to the Marquesas Islands. There, a French ship-of-war should take the exhibition to Caroline and Flint Islands, which are both near the central line of the eclipse.—*Les Mondes*, December 30, 1882. C.

Striking the Hours by Electricity.—J. Laugé, a watchmaker of Béziers, takes the electric wire of a battery which controls an electric bell, and attaches it to some metallic part of the movement of a clock. The positive wire, suitably insulated from other parts of the clock, is fastened, so that its extremity will be just over the handle of the hammer. When the clock strikes the hammer rises, and its handle rubs the positive wire, so as to form the contact. At the same moment, the other bells which are in the circuit strike the same hours as the clock. The system might be applied to church bells. Even the great bell of Notre Dame might be swung by a little clock, so as to strike synchronously with it, by means of a sufficiently powerful electromagnet.—*L'Electricien*, No. 40. C.

Adulteration of Food.—The municipal laboratory of Paris during the two years of its existence has rendered valuable service to the citizens. Those who practice the adulterations often display an amount of skill which would be more than sufficient to gain an honest fortune. The manufacture of spurious gooseberry jelly furnishes an example. The jelly is made from seaweed, the color from fuchsine, or some other similar material, and the flavor is given by a compound in which there is not a drop of gooseberry juice, but which is composed of 5 parts acetic ether, 4 parts tartaric acid, 1 part benzoic acid, 1 part succinic acid, 1 part aldehyde and œnantic acid. M. Girard, the director of the laboratory, gives also the composition of nine other chemical compounds for imitating the flavors of strawberry, pineapple, melon, apple, pear, cherry, peach, apricot and plum. Flour is exposed to dampness, in order to make it weigh heavier; the gluten is

thus altered, being rendered less fit for breadmaking and more liable to mould. Wheat flour is mixed with flour of beans, peas, lentils, maize, and even with potato starch. The most guilty adulteration consists in mixing with flour mineral products which are often poisonous, such as lead, copper, zinc, sulphate of lime, and chalk. Flour has been imported into France from Rotterdam, which contained as much as 30 per cent. of plaster, or as much as 20 per cent. of sulphate of barytes. Out of thirty-one specimens of flour which were examined at the laboratory only thirteen were found to be pure.—*Les Mondes*, Nov. 25, 1882. C.

Preservation of Honey.—According to Vogel, honey contains about one per cent. of fornic acid on the average. E. Mylins observed that crude honey kept better than that which had been clarified; hence he was led to try the addition of formic acid, and the result was very satisfactory. The acid seems to hinder fermentation, without altering the taste of the honey.—*Les Mondes*, April 14, 1883. C.

Water Motor for Clock Work.—M. Tillac, of Tulle, has devised a drum which is divided into an equal number of cells, arranged around a central arbor. A quantity of liquid is introduced into the interior of the drum, sufficient to fill about two of the chambers, and a cord to which a weight is suspended, is rolled around the arbor. The liquid is then raised on the opposite side until equilibrium is established. The cells communicate by small orifices, near the circumference of the drum, so that the liquid tends to flow constantly downward while the weight tends to carry it upward. The amount of liquid and the weight can be so adjusted as to obtain a rotary movement as slow as may be desired.—*Les Mondes*, April 14, 1883. C.

Use of the Palmetto.—The constant increase in the demand for paper, cordage, and woven fabrics, stimulates the search for fibrous materials which may be used in the place of rags and straw. In Algiers, by the side of the Alfa and Ramie grows a plant which is not less valuable for its textile properties; it is the dwarf palm tree, a wild plant greatly dreaded by agriculturists. The Arabs have long known the fibrous properties of this shrub; but they have never utilized any portion but the leafy tops. A Frenchman, M. Reynaud, has found a use for the entire plant; the roots being employed for heating, and all the rest being transformed into fibres of a superior quality.—*Chron. Industr.*, March 25, 1883. C.

List of Books added to the Library during July, August and September, 1883.

Academia Real das Sciencias. Lisboa.
Sessão publica. June, 1880.
Conferencias celebradas na Academia Real das Sciencias de Lisboa. 1880.
Journal de Sciencias.
Historia dos Estabelecimentos Scientificos de Portugal. Por J. S. Ribeiro. Vols. 7–9.
Presented by the Academy.

Almanaque Nautico para 1883 y 1884.
Presented by El Instituto y Observatorio de Marina de la Ciudad de San Fernando.

American Journal of Railway Appliances. New York, 1883.

American Society of Mechanical Engineers. Transactions. Vols. 2 and 3. 1881 and 1882. New York.
Presented by the Society.

American Water Works Association. Report of Third Annual Meeting. Buffalo, 1883. Presented by the Association.

Apprentices' Library, Philadelphia. Sixty-third Annual Report of the Managers. 1883. From the Library.

Astronomical Papers for use of the American Ephemeris and Nautical Almanac. Part 3. Vol. 1. Washington, 1880.
Presented by the Navy Department.

Bell, T. J. Water Supply of the World.
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Bibliotheca Historico-Naturalis et Mathematica. Catalogue of R. Friedländer & Sohn. Berlin. Presented by the Publishers.

Blake Manufacturing Company's Illustrated Catalogue of Pumps and Pumping Machinery. New York, 1883.
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Presented by the Board.

Board of United States Naval Engineers. On an Air Refrigerating Machine. Washington, 1883.
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Board of Water Commissioners City of Detroit. Annual Reports, 1854–1880. Presented by the Board.

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Presented by the Ministre du Commerce.

Brooklyn Library. Twenty-fifth Report of the Board of the Directors. 1883. Presented by the Library.

Bureau of Education. Circulars of Information. Nos. 1 and 2. 1883. Washington. Presented by the Bureau.

Bureau of Statistics. Quarterly Reports of the Chief. 1877, 1878–9; 1879–80; 1880–1; 1881–2; 1882–3. Presented by the Bureau.

Burn, R. S. Steam Engine. London, 1857.

Cassino, S. E. International Scientists' Directory. Boston.
Presented by the Author.

Census Dep't U. S. Compendium of the 10th Census. Parts 1 and 2. 1880. Presented by the Interior Dep't.

Chicago Public Library. Eleventh Annual Report of the Board of Directors. June, 1883. Presented by the Board.

Cincinnati Water Department. Forty-first Annual Report. 1880.
Report of the Board of Public Works. 1881 and 1882.
Presented by the Chief Engineer.

Colorado Agricultural College. Fourth Annual Register. 1881–2 and 1882–3. Presented by C. L. Ingersoll, Pres't.

Colorado State Board of Agriculture. Report for 1881–2. Denver, 1883. Presented by the Board.

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Commerce of the World, and the Share of the United States therein. Washington, 1883. Presented by the Dep't of State.

Dixwell, G. B. The Premises of Free Trade Examined. Cambridge, 1881.

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Du Moncel et Geraldy. L'Électricité comme force Motrice. Paris, 1883.

Edinburgh Journal of Science. Brewster. London, 1826–1832.

Fortifications of To-day. Washington, 1883.
Presented by Chief of Engineers, U. S. A.

Franklin Institute Journal. 1866, 1870 to 1875.
Presented by Rev. H. J. Morton.

Geological Survey of India. Memoirs. Palæontologia Indica. Ser. 10. Vol. 2. Calcutta, 1883. Presented by the Survey.

Geraldy, F. See Du Moncel.

Greer, H. Recent Wonders in Electricity.
Presented by the Author.

Halifax. Report on Means of Preventing Loss by Fire. 1883.
Report on the Proposed Dry Dock for the Port. 1883.
Reports of the Board of Works. 1881–82.
Schemes of Sewerage for the City. 1876.
Presented by the Chief Engineer Water Dep't.

Health Dep't of Wilmington. Reports of President and Secretary. 1882 and 1883.
Condensed Statement of Yearly Mortality. 1880.
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Hill, J. W. Pocket Manual for Engineers. Providence, 1883.
Presented by Wm. A. Harris.

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Insurance Chart. Philadelphia, 1883.
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Presented by the Society.

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Montreal Water Works. Report of the Superintendent for 1853, 1862–75; 1877–82. Presented by the Chief Engineer.

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Abridgements of Specifications Relating to Electricity and Magnetism. Div. 3, Part 2. 1867–1876.
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Subject Matter Index of Patents. 1882–1883.

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Presented by G. Murdoch, Chief Engineer.

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Presented by the Chief Signal Officer.

Smithsonian Institution. Annual Report of Board of Regents for 1881. Washington. Presented by the Institution.

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Society of Engineers. Transactions for 1882. London.
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Spring Garden Institute. Thirty-Second Report of the Board of Managers for 1882–83. Presented by the Board.

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Sugar-Beet Culture in France and U. S. Report. Washington, 1880. Presented by the Department of Agriculture.

Surgeon-General of U. S. Navy. Sanitary and Statistical Report. 1883. Washington. Presented by the Surgeon General.

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University of Tokio, Japan. Calendar of the Department of Law, Science and Literature. Measurement of the Force of Gravity at Sapporo. Presented by the University.

Urquhart, J. W. Electromotors. Manchester: Emmott, 1882.

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Water Supply of Charlottetown. Report. Presented by G. Murdoch.

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Woman's Silk Culture Association. Third Annual Report. 1883. Presented by the Association.

Wyoming Historical and Geological Society Proceedings. Nos. 4 and 6. Wilkesbarre, 1883. Presented by the Society.

The Library is now in possession of complete sets of the London, Edinburgh and Dublin Philosophical Magazine and Journal of Science, commenced in 1797 under the title of Nicholson's Journal of Natural Philosophy, Chemistry, and the Arts; of

The Phonetic Journal, by Isaac Pitman (with a single exception the only complete set in the United States), which will be highly appreciated by those interested in the question of spelling reform; of

The French Patents as far as published by the French Government; and of all the Coast Survey Charts thus far published by the United States Government.

E. HILTEBRAND, *Librarian.*

Franklin Institute.

[*Proceedings of the Stated Meeting, held September* 19, 1883.]

HALL OF THE INSTITUTE, Sept. 19, 1883.

The meeting was called to order at the usual hour, with the President, William P. Tatham, in the chair. There were present 91 members and 10 visitors.

The minutes of the last stated meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at the stated meeting of the Board, held Wednesday, September 12th, 20 persons had been elected to membership in the Institute.

The President gave an account of the present condition of the work upon the International Electrical Exhibition, which the Institute proposes to hold in September, 1884.

The special committee appointed to revise the existing method of presenting papers for reading and discussion at the meetings, made the following report, viz.:

Report of Joint Committee of Meetings and Publication, on the Reading of Papers before the Institute.

The suggestions submitted to this committee relate to two distinct subjects—that of greater interest and usefulness in the monthly meetings, and that of reporting such discussions as the papers read may evoke. To accomplish the first and more important purpose it is proposed to do away, as far as possible, with mere matters of business at the monthly meetings, to shorten the time allowed for the reading of papers, to require that the latter shall be actual essays prepared beforehand and not impromptu speeches, and to have slips of such papers printed before the meeting and circulated among members interested in the subject, that they may be prepared to discuss it intelligently.

To effect the changes suggested it is necessary to amend the By-laws in Article XIII, relating to the order of business. The amendments proposed have the effect of postponing the routine business matters until after the reading of papers, etc., so that the discussion of subjects of scientific and mechanical interest shall have the preference. If then, there should not be time for the transaction of business, special meetings may be held, if necessary, to attend to such matters. The amendment proposed is as follows:

Strike out Section 2 of Article XIII, and insert as follows:

Section 2.—The order shall be as follows:

1. Reading of Minutes.
2. Secretary's report of progress in science and the arts.
3. Paper or papers announced for the evening, followed by discussion thereon.
4. Secretary's report on exhibits of new inventions.
5. Reports from the Board of Managers.
6. Reports from the Standing Committees.
   (1.) On Library.
   (2.) On the Cabinet of Minerals.
   (3.) On the Cabinet of Models.
   (4.) On the Cabinet of Arts and Manufactures.
   (5.) On Meteorology.
   (6.) On Meetings.
   (7.) On Science and the Arts.
   (8.) The Curators.
7. Reports from Special Committees.
8. Reports from Sections.
9. Deferred business.
10. Consideration of new business.

Section 3.—Not more than twenty minutes shall be allowed for the reading of a paper, and the discussion thereon shall be limited to forty minutes, no speaker being allowed more than ten minutes.

Change the numbers of Sections 3 and 4, to 4 and 5.

The following rules of procedure have been adopted by the Committee on Meetings and Publication, viz:

One member of the Committee on Meetings and one of the Committee on Publications shall be appointed to act each month as readers, and determine provisionally, each for his committee, whether the papers submitted shall be read and printed in the Journal. If they agree, and the Committee on Meetings approves, the Secretary shall have the paper set in type, and fifty galley slips thereof taken, ten of which shall be retained in the library until after the reading, for the use there of members, and the remainder shall be distributed to such members as may apply for them until the stock, less the ten to be retained, is exhausted. The Secretary shall give notice on the notices of the meeting, of the title of the paper and of the printing of the slips. If the paper is to be read, but not printed in the Journal, slips may be printed and distributed as above at the expense of the author. If the paper is to be printed but not read, the members will receive it in the Journal, and no other printing is to be permitted. The paper must be submitted to the Secretary not less than ten days preceding the meeting at which it is to be read, and he shall immediately send it to the representative

of the Committee on Meetings for the month. The latter shall submit the paper, after he has passed upon it, to the representative of the Committee on Publication for the month, in time to allow the latter to return the paper on, or before, the second Wednesday of the month. The paper shall be reported to the Committee on Meetings, which shall take final action as to the reading. If slips are to be printed, the Secretary shall have them ready for the members on the Monday preceding the monthly meeting.

The members shall serve as representatives in rotation, in an order determined by the chairman. In case of absence or inability of the representative to attend to his duties, the next on the list shall be notified by the Secretary to act in his place, and so on through the list.

The Committee on Publication may review the action of their reader and reject a paper finally, but his approval shall be sufficient to authorize the printing of galley slips.

In respect to reporting the debates, we find that no action is required by the committee or Institute. The By-laws, Section 2 of Article VII, prescribe as one of the duties of the Secretary that he shall report or cause to be reported the proceedings of the Institute and shall deliver the report thereof or an abstract of it to the editor for publication. The committee, however, would suggest to the Secretary that in the exercise of this power, he have full reports made of the discussions and printed on the type-writer for preservation in the library. Those which are deemed of sufficient importance may be printed in full in the Journal, and of the others, abstracts can be printed.

They would also recommend that to put the changed programme into operation at once, the order of business be temporarily changed by vote at the September meeting in accordance with these suggestions. Also, that the following resolution be submitted to the Institute at the September meeting:

Resolved, That the Secretary be authorized to provide an automatic signal bell that can be set to ring at an appointed time, and that when a speaker begins to read his paper it shall be his duty to set the bell to ring at the end of twenty minutes, after which signal the reading shall be stopped, unless unanimous consent is given the speaker to continue.

Under the proposed plan an essayist having a paper he desired to read would have to send it to the Secretary ten days before the meeting. The readers for the month would have three days in which to consider it at their leisure, not being required to meet for the purpose. The

paper would then be submitted to the Committee on Meetings at its meeting on the second Wednesday evening. Action there would be final as to its reading and printing on galley slips, the Secretary being thus given four working days in which to have it set in type, and the members two days in which to read and consider it before the meeting. The Committee on Publication would in the meantime or afterwards review the action of their reader. This should secure well-digested papers and intelligent discussion.

On motion of Mr. Hector Orr the consideration of the report was postponed until the October meeting.

A paper by Mr. Joseph Sharp, of Cincinnati, on "Oil-Dressed Belting," was read, in the absence of the author, by the Secretary. The paper was discussed by Messrs. J. W. Nystrom and Hugo Bilgram. It appears in the JOURNAL for October.

A paper by Mr. Robert Grimshaw, on "The Indicator as a Detector of Lost Motion," was read by title. It appears in this issue of the JOURNAL.

The Secretary's report comprised a review of the present condition of several important engineering projects, and a description of a number of new inventions, among which were included the following: The Blackman Exhaust Fan, an apparatus designed for ventilating purposes, and which is claimed by its makers to embody several features of construction, which add greatly to its capacity, utility, and economy, as compared with other devices for the same purpose. A new Reversing Gear for locomotive and other engines, invented by Fred. Rock, of Homer, N. Y., and the object of which is to supersede the link motion and other devices used for reversing or shortening the travel of the valve, to cut off steam at different parts of the stroke of the piston, in order that the steam may be used expansively at any time when the full stroke is unnecessary. An improved portable Fire-Escape, invented by H. H. Little, of Camden, N. J., composed of a series of extension-ladders connected with a lazy-tongs mechanism, by which they may be rapidly extended to full length and lowered, in which latter state the whole apparatus is compactly folded up. The actuating mechanism is a spring, the coiling of which lowers the apparatus; while releasing it, by the withdrawal of a pawl from a ratchet wheel which it carries, extends the apparatus to its full height. From the top of each ladder lateral platforms extend, which may be inclined so as to bring them opposite the windows of a building, and by means of which persons

may pass from the windows to the ladders. A basket may also be raised and lowered by means of ropes passing over pulleys on the projecting arms of the upper section. The whole apparatus is mounted on a truck, which enables it to be rapidly transported and moved into any position with reference to a burning building where it may be needed.

The so-called "Calorific Positive Pump," invented by Mr. C. L. Riker, of New York, was exhibited in operation, and may be described in general terms as follows:

A steam generator contained within a cylindrical base, using gas as fuel, supplies steam to a copper cylinder situated above it, displacing the water contained therein until about three-quarters of its contents have been driven out, when the steam is suddenly condensed, forming a vacuum therein, the result of which is that the cylinder becomes again filled with water from the well, cistern or other source of supply. The above operation is then repeated. It should be stated that the pump is filled with water before it is started, after which it will always keep itself supplied and, if necessary, will work continually until either the water or gas fails to supply it. There are no working parts except the check valves in the suction and discharge pipes. It is an alternating vacuum and steam pressure pump, entirely automatic, after the ignition of the gas. It vaporizes at each discharge about one tablespoonful of water (for No. 5 size), and the construction is such that it is impossible to generate a greater amount of steam than is just sufficient to effect each intermittent discharge.

The consumption of gas is said to be 20 cubic feet per hour for 200 gallons of water raised 50 feet high.

Specimens of the so-called "Magneso-Calcite," a new fire-proof material, manufactured by the Magneso-Calcite Fire-proof Company, of Boston, were shown and described. The material, which takes the form of slabs, sheets, etc., of any desired form, consists of a number of layers of fibrous materials (mineral or vegetable), thoroughly incorporated, with the aid of water, with clay, magnesia, lime, talc, or similar refractory materials.

This is made into layers, sheets, or any other desired form, and is then saturated with a solution of a salt of lime, alum, borax, silicate or tungstate of sodium, or other incombustible salt. Thus prepared, the sheet, slab or what not, is covered on one or more sides with a lining made preferably of vegetable or mineral fibre, or a mixture of